Hanlon Creek Business Park
2013 Consolidated Monitoring Report

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NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists

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2013 Consolidated Monitoring Report

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Report submitted on January 18, 2016

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<u>Introduction</u>

A consolidation of the monitoring on the Hanlon Creek Business Park (HCBP) Lands is required as a condition of approval of the *HCBP Environmental Implementation Report 2009* (EIR) prepared by Natural Resource Solutions Inc. Standard Operating Procedures for this monitoring can be found in a report titled *Hanlon Creek Business Park Consolidated Monitoring Program*, prepared by NRSI in 2010.

Pre-construction monitoring began in 2006 and continued for 4 years. Construction-phase monitoring began in 2010. Monitoring occurs either at specific times of the year, and certain components of groundwater and surface water occur year round. Annual reporting occurs according to the calendar year. A Rapid Assessment and Action Protocol (RAAP) is in place to address immediate monitoring concerns, with a focus on surface water temperature and turbidity. The RAAP group includes representatives of the City of Guelph, the Grand River Conservation Authority, and the consulting team. Monitoring is the responsibility of the City of Guelph, as the developer representative, and will continue until the time when 75% of the area of each of Phases 1 and 2 is built, plus an additional 2 years. It is anticipated that this timeframe will also apply to Phase 3.

Construction commenced in late 2009 and has continued each yearand through 2013. Construction activity in 2013 included the construction and operation of industrial buildings on Block 9 and Block 10 on Phase 1 lands as well as construction of the Laird Road overpass of Phase 2 lands. No construction activity occurred within Phase 3 in 2013. Construction inspection in 2013 was conducted by Natural Resource Solutions Inc.

Performance monitoring in 2013 was conducted by Banks Groundwater Engineering Limited, AECOM and Natural Resource Solutions Inc. Monitoring components included groundwater levels, temperature and water quality at 37 monitoring wells and 19 mini-piezometers; stream flow, temperature and water quality at 12 stream stations and within 3 stormwater management ponds; fish and benthic invertebrates at 5 stream stations; and vegetation, breeding birds and amphibians at 11 vegetation plots.

Results

Groundwater levels were notably high in 2013 compared to results from 2012, which saw levels at the lowest recorded since monitoring began in 2003 at many of the monitoring locations. Levels in 2013 were influenced by fluctuating daily air temperatures between January and March, above average precipitation in January, April, June, and July, and above-freezing maximum daily air temperatures between late-March and late-November, which allowed infiltration into the groundwater system. While groundwater levels began the typical decline in May, the above-average precipitation in June and July maintained levels across the site above the low levels observed during the previous summer.

During the months of January, February and March 2013, groundwater levels at Core PSW monitoring stations were within the typical ranges for this time of year. Groundwater levels in most monitors then began declining during April and continued to decline through to late-September. The lowest levels observed in 2013 varied from location to location, but most occurred during September. At almost all locations where data loggers had been in place for more than two years, the 2013 summer levels were above the low levels observed during the drought in the summer of 2012. Monitoring in the Downy Road PSW, and in Tributaries A and A1 showed similar groundwater levels and responded to climatic factors similar to the Core PSW monitors. Groundwater elevations vary more widely over the year at perimeter locations in comparison to the Core PSW locations.

Climate had the greatest if not only influence on groundwater elevations across the HCBP in 2013. There were no apparent short-term and/or longer-term changes in groundwater levels that could be attributed to construction activities during 2013 within the HCBP.

Surface water baseflow levels were influenced by higher average precipitation levels in 2013 compared to the previous year but because of a small number of months receiving very little precipitation it can be concluded that the precipitation levels experienced in 2013 were about average. Higher precipitation amounts for both the winter and spring months lead to a much healthier snowmelt and groundwater recharge period compared to 2011 and 2012, which helped to increase and maintain baseflow levels throughout 2013. Higher precipitation levels contributed to increased baseflow measurements as eight out of the 10 stations recorded greater baseflow averages than 2012. Only stations HC-A(11) and HC-A(13) experienced average baseflows lower than those observed in 2012. Unlike 2012, no period of intermittent flow was recorded in 2013.

Constant discharge from Stormwater Management (SWM) Pond 4 was not anticipated as part of the design, but in 2013 it once again augmentedbaseflow within Tributary A, similar to 2012. This baseflow augmentation was most noticeable in the vicinity of Laird Road, including a station located a short distance downstream (north) of the road. While this augmentation of flow increased the habitat availability in Tributary A, it also contributed to elevated stream temperatures in Tributary A during the summers of 2012 and 2013. While stream temperatures have often been elevated in the downstream reaches of Tributary A on the HCBP lands, the elevated temperatures in 2013 occurred upstream as far as SWM Pond 4 due to its influence.

Groundwater quality was generally within the applicable Ontario Drinking Water Quality Standards (ODWQS) criteria for concentrations of the parameters analyzed, with some exceptions for nitrate, metals, sodium and hardness. Colour, turbidity, total dissolved solids and dissolved organic carbon (DOC) generally exceeded the respective ODWQS concentrations, and this is typical for these parameters in monitoring wells.

For surface water quality, the majority of the stream sites were within the ranges of the Provincial Water Quality Objectives (PWQO). During the stream baseflow monitoring events, the dissolved oxygen (DO) was at times below PWQO levels at three of the nine stream stations, usually as a result of below average flow rates due to high temperatures and an extended period of no precipitation.pH levels were above or below PWQO guidelines at four of the nine stream stations. These included three measurements (two above and one below) in the upstream section of Tributary A as well as one measurement (slightly below) at three other stations located in the upper, middle, and lower portions of Tributary A. Monitoring of turbidity at four stations occurred in 2013, although a number of issues resulted in inaccurate readings at each location. These issues included sensor error, sediment covering the sensor, biofouling and vegetation growth, all of which interfered with sensor readings.

Benthic invertebrate monitoring results showed significant declines in taxonomic richness at all stations, a decline in Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa at two of five stations, and a shift in the dominant taxon at two stations to the species *Orthocladiinae*, a species of Dipteran belonging to the family Chironomidae. The Percent Model Affinity (PMA) analysis yielded results of 'impact' at three of five stations, which occurred for the second consecutive year at two of these stations and for the third consecutive year at one station. The decline in taxonomic richness at the five stations was attributed to variations in the benthic identification process. It is expected that the above average precipitation and increased baseflows throughout the downstream reaches of Tributary A likely had some influence on the benthic invertebrate community at three of the stations, providing potential explanation for the variation in EPT taxa and the shifts in the dominant taxon and the PMA impact determinations. The decline in taxonomic richness resulted in threshold exceedances at all five stations in 2013. Threshold exceedances for PMA analysis were also noted at two stations where an 'impact' determination was noted for the second consecutive year.

During 2013 aquatic monitoring a total of 735 individual fish were captured representing seven different species. The total catch in 2013 is by far the highest that has been recorded since sampling began in 2006. The elevated numbers of fish captured are believed to be associated, in part, to the above average precipitation and increased baseflows. All species captured in 2013 exhibit a coolwater thermal regime preference, with the exception of the fathead minnow(*Pimephalespromelas*). Fathead minnow, which was captured for the first time in 2011, was again captured in 2013. Population estimates increased substantially at all five monitoring station.

Vegetation monitoring in 2013 showed largely stable vegetation conditions with only a few exceptions. The coefficient of wetness continued to show that two plots (Plots 3 and 5) are upland sites while the remaining nine plots are in wetlands. Three plots (Plots 1, 5 and 9) demonstrated a continuing trend of increasing wetness, while two plots decreased in wetness (Plots 16 and 18). The coefficient of conservatism (CC) values at nine of the plots show average results between 4 and 6, meaning the plant species are associated with a specific plant community but can tolerate moderate disturbance. Two of the plots (Plots 6 and 9) have values between 2 and 3 indicating the presence of plant species that are more tolerant of disturbance. The Natural Area Index (NAI) values decreased at 8 plots and increased at 3 plots (Plots 1, 6 and 7) in 2013, however the values are still considered to be generally lower than in previous years. The NAI combines the CC with native species to provide a more stable assessment of the vegetation. Stations generally remained within the range of values from previous years, however many continued to decline to the lowest levels experienced. It is believed that the drought conditions in 2012 are likely to have a lingering effect on the NAI values for most of the stations.

The numbers of non-native species have remained stable throughout monitoring from 2006 to 2013. A total of 110 herbaceous species were recorded in 2013 compared to 75 in 2012. A total of 10 herbaceous species were recorded for the first time in 2013 including six native species. This included the noteworthy addition of three species (swamp thistle (*Cirsiummuticum*), fen twayblade (*Liparisloeselii*) and bog goldenrod (*Solidagouliginosa*)) that have wetland affinities and are indicators of rich, intact swamp habitat. In 2013, 21 shrub species were recorded. This number has varied over the monitoring years from a low of 15 species in 2007, 2008, and 2009. Three new shrub species were observed in 2013 including gray dogwood, woodbine, and western poison ivy. Similar to previous monitoring years, trees were absent from three monitoring plots and dominant species found within each plot did not change from previous years. As well, no notable changes were observed in tree species composition or tree health within any of the monitoring plots between 2013 and previous years. Given the limited number of ash trees within vegetation monitoring plots it is difficult to observe any large-scale decline of ash trees due to Emerald Ash Borer (EAB) (*Agrilusplanipennis*). No signs of EAB were detected within the monitoring plots in 2012. Although slight variation in soils is observed from year to year, the overall composition and moisture regimes have stayed fairly consistent from 2006 to 2012.

Of the 50 bird species observed during breeding bird monitoring in 2013, 21 exhibited possible breeding evidence, 24 exhibited probable, three were confirmed, and two showed no breeding evidence. The most abundant species observed during 2013 surveys was song sparrow (*Melospizamelodia*), making up 13.0% of the observations during breeding bird point counts. This was followed by American robin

(*Turdusmigratorius*) with 11% andred-winged blackbird (*Agelaiusphoeniceus*) at 10%. These species were also the most abundant in 2010, 2011 and 2012.

Breeding bird species diversity in 2013 was average to higher than average than 2013. A marked increase in diversity was observed at Plot 11, which had showed a consistent decline between 2009 and 2012. This increase was attributed to the decrease in construction activity in Phase 2 in 2013. Within Phase 3 lands plots generally maintained a high diversity of grassland bird species, which included probable breeding evidence of both bobolink (*Dolichonyxoryzivorus*) and eastern meadowlark (*Sturnella magna*). In general the 2013 breeding bird abundance reflects the 2012 abundance on a plot-by-plot basis with notable increases in bird abundance at four plots. Eight of the 13 plots showed the highest recorded abundance of birds since monitoring began in 2006. No notable decreases were observed between 2012 and 2013 and long-term trends appear to show steady numbers or slight increases in abundance between 2006 and 2013.

NRSI observed three bird species that are considered Threatened federally and provincially (COSEWIC 2013, OMNR 2013): barn swallow (*Hirundorustica*), bobolink, and eastern meadowlark. Bobolink was listed as Threatened by COSEWIC and COSARRO in 2010, while barn swallow and eastern meadowlark were augmented in 2011. Observations of bobolink were made at Plot 9 and Plot 20 showing probable breeding evidence and incidental observations were made outside of the breeding bird survey period. Barn swallow was observed with possible breeding evidence at Plot 1 and Plot 19. Eastern meadowlark was observed at five stations in and around the Phase 3 lands, showing possible breeding evidence at four stations (Plots 1, 6, 9 and 11) and showing probable breeding evidence at Plot 20.

Four amphibian species were recorded during evening call count surveys in 2012: spring peeper (*Pseudacris crucifer crucifer*), wood frog (*Lithobates sylvatica*), American toad (*Bufoamericanus*) and gray treefrog (*Hyla versicolor*). Spring peeper was the most abundant and most widely distributed species, recorded at seven plots in 2013. Three to four species have been recorded regularly in previous monitoring years. Six species were recorded during 2009 surveys and none were recorded during the first preconstruction monitoring year (2006). Although observed in low numbers in previous years, monitoring in 2013 did not detect pickerel frogs (*Rana palustris*), or western chorus frogs (*Pseudacristriseriata*). Monitoring thresholds for amphibians were reached at some plots in 2012. There was a decline in the species abundance measured by a decrease in two call codes at three of the plots.

<u>Issues</u>

Water temperatures in Tributary A were elevated for the second year during the summer of 2013. Surface water monitoring in 2013 experienced exceedances of 22.0°C at 10 of 11 surface water monitoring stations and 24.0°C at eight of 11 monitoring stations along Tributary A and Tributary A1 of Hanlon Creek. Temperatures continued to exceed in the headwater reaches of the creek, downstream of SWM Pond 4 in addition to the more typical exceedances occurring in the furthest downstream reaches. Although exceedances were still observed at a similar number of stations in 2013 compared to 2012, surface water monitoring results showed a decrease in the frequency and overall duration of 22°C and 24°C exceedances at all stations. Between July and August of 2012, stations HC-A(04) and HC-A(06) exceeded 22.0°C a total of 61.0% and 46.0% of the time, respectively and exceeded 24.0°C a total of 12.0% and 13.0% of the time, respectively. In 2013 both of these stations exceeded 22.0°C a total of 7% of the time, and exceeded 24°C a total of only 1.0% of the time. These elevated water temperatures are of concern based on the goal of maintaining a suitable thermal regime for brook trout, a cold water fish species that inhabit the Hanlon Creek system.

In the spring of 2013, elevated water temperatures throughout the downstream portion of Tributary A resulted in exceedances of 24°C at monitoring stations HC-A(13) and HC-A(14). These stations are both located downstream of the outlets from SWM Pond 1. Several factors are believed to have contributed to the elevated water temperatures throughout the downstream portions of the site. These include climatic conditions and station characteristics as well as potential influences from SWM Pond 1. Climatic conditions are likely to have had the greatest influence on the temperatures experienced throughout the downstream sections of Tributary A. This is due to the fact that the stations are quite exposed and exhibit relatively high daily variations in temperature throughout the summer months due to a greater potential for solar radiation. A combination of climatic and SWM Pond 4 factors also led to the exceedances noted above and the overall warming of Tributary A downstream of the SWM Pond 4 outlet in

2012. Although exceedances were still observed at a similar number of stations in 2013 compared to 2012, surface water monitoring results showed a decrease in the frequency and overall duration of 22°C and 24°C exceedances at all stations. However, the trend of increasing temperatures at reaches downstream of SWM Pond 4continued throughout 2013. Surface water monitoring stations upstream and downstream of the SWM Pond 4 outlet continue to indicate that the water flowing from the Pond 4 cooling trench is acting to increase temperatures within Tributary A.

It was also determined that surface water from SWM Pond 4 could be migrating toward Tributary A through the ground as another pathway from SWM Pond 4 to Tributary A, and could also have caused warming of the water in Tributary A. The groundwater with elevated temperatures was also discharging through the cooling trench due to the groundwater interactions that lead to continuous discharge of groundwater through the trench. Groundwater monitoring results identified elevated groundwater temperatures at groundwater monitoring station MW119A, located adjacent to and down-gradient from SWM Pond 4. There was most likely an effect on Tributary A, although the extent is unknown. Additional mini piezometers were installed at the beginning of 2013 near the outlet of SWM Pond 4 to further explain the elevated temperatures that were being seen. These monitors showed slightly elevated temperatures within the groundwater system at the outlet of the pond. Plantings were installed within and around SWM Pond 4 in 2012 with the objective of reducing solar warming of the water by blocking solar radiation. It remains to be determined whether or not this measure will succeed, although it was noted in 2013 that vines were beginning to establish, growing over the cooling trench. If successful in mitigating the increase in water temperatures in the pond, it will also serve to mitigate the warming effect on Tributary A via the groundwater pathways. However, it may take several additional growing seasons for the plantings to establish sufficiently to have the desired mitigating effect.

Four benthic monitoring stations (BTH-001, BTH-003, BTH-004, and BTH-005) experienced threshold exceedances in 2013. Two stations (BTH-003 and BTH-004) exceeded the threshold for PMA analysis, which was an “Impact” determination at a station for two consecutive years following two consecutive years where the determination was “No Impact”;station BTH-005 exhibited a 50% decline in the total number of taxa as compared to the results from the previous year; and station BTH-001 exhibited a 50% decline in the number of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa as compared to the average results from the previous 2 years. It was difficult to determine the cause of these exceedances since habitat conditions were quite different in 2013 compared to 2012. However, there was no indication that these exceedances were a result of construction-related activities.

In 2013, the 25% herbaceous cover threshold was exceeded in Plots 2 and 3. The Plot 2 threshold was exceeded positively due to an abundance of spotted jewelweed and has been interpreted as a positive change within the plot. The herbaceous cover in Plot 3 (9.1%) was reduced by almost 49% from the preconstruction average (57.8%).As this plot is outside of the construction areas this change in herbaceous vegetation cover is difficult to explain. At this time, it is believed that recent years of below-average precipitation are responsible for the decrease in ostrich fern within the plot and subsequently a decline in herbaceous cover.

A change in herbaceous species diversity by 25% was observed at five stations in 2013. An increase by more than 25% was observed at four plots while a decrease of more than 25% was noted at one plot. An increase in species diversity is generally associated with a benefit to the natural environment, unless the increase is due to an introduction of a non-native, invasive species.Despite the decrease of 25% at one plot, it was noted that this plot shows consistently low species diversity due in part to a dense canopy of conifers. Herbaceous species in this plot tend to exist sporadically in low numbers and may be present one year yet while they have senesced or died off in another, less favourable year.

A decrease in two calling codes was observed at three plots in 2013. It is likely that the changes observed are a result of dry conditions in 2012 coupled with nearby construction activity. Dry conditions may have led to desiccation of egg masses or tadpoles, increased mammal predation or the movement of adult anurans to other vernal pools in search of better breeding habitat. The low levels of anuran activity in 2013 may be a reflection of impacts sustained during the spring of 2012.

Corrective Measures Undertaken

No corrective measures were undertaken in 2013. It was decided that the corrective measures undertaken in 2012 should continue to be monitored for effectiveness throughout 2013 and into 2014 before making any changes. The corrective measures undertaken in 2012 included: raising the outlet of the cooling trench at Pond 4 (this was removed in early 2013), raising the weir level at the pond outlet at Pond 4, and planting of aquatic vegetation throughout the shallow areas of the pond as well as planting vines and herbaceous species in and around the cooling trench at Pond 4.

Recommendations

In general, the groundwater, surface water, fish, benthic invertebrate, vegetation, breeding bird and amphibian monitoring should continue as per the Standard Operating Procedures for the Consolidated Monitoring Program (NRSI 2010). For 2014, it is recommended that monitoring give diligent attention given to stream temperatures and the SWM Pond 4 mitigation measures put in place to date. Particular attention should be given to monitoring wells MW119A,PZ-13D, and PZ-14D regarding the temperature effects of SWM Pond 4. The RAAP should continue to function as prompted by any stream temperature or turbidity exceedances, or other observations of concern.

Monitoring of stormwater management ponds should continue as in 2013 to monitor their effectiveness, including the bottom draw outlet and cooling trench performance. It is recommended that the temperature loggers in the Pond 1 cooling trench outlets be replaced with depth/temperature loggers to determine the relative flows out of each cooling trench to establish if one or the other cooling trench may be passing more flow and influencing temperatures more. It is recommended that the depths of loggers at loggers at HC-A(11) and HC-A(14) be adjusted in 2014 to avoid sediment overcoming the sensors and that turbidity sensors be maintained more frequently to ensure usability of data.

Conclusions

Monitoring at the Hanlon Creek Business Park in 2013 was successful in providing useful information to describe environmental conditions on site, detect issues and develop solutions. Elevated stream temperatures and the contributing temperature impacts from SWM Pond 4 continued to be the most prominent issue in 2013, however the data has improved from 2012. Standard operating procedures for data collection are expected to provide the information required to further address the issues discussed in this report.

1.0 Introduction

The monitoring program associated with the Hanlon Creek Business Park (HCBP) is an integration of a series of monitoring requirements arising from recommendations made in the Consolidated Environmental Impact Study (NRSI 2004), the Draft Plan Conditions (Ontario Municipal Board (OMB) 2006), and review comments from agencies during the various stages of the planning process. A consolidation of the monitoring on the HCBP Lands is required as a condition of approval of the *HCBP Environmental Implementation Report 2009* (EIR) prepared by Natural Resource Solutions Inc. (NRSI 2009). The City of Guelph (the City) Environmental Advisory Committee (EAC) recommended approval of the EIR, with a list of conditions that should be met prior to registration of the plans for Phases 1 and 2. Condition 8 states:

> *That a comprehensive and consolidated monitoring program, which specifies frequency, location, protocols, timing, thresholds, and specific contingency measures be submitted and approved by the City of Guelph and the GRCA[Grand River Conservation Authority].*

To meet the above condition, a documenttitled *Hanlon Creek Business Park Consolidated Monitoring Program* (NRSI 2010) was created as a reference document containing the standards that are to be followed in carrying out the Consolidated Monitoring Program. Refer to that document for detailed information on the framework of the monitoring program and the Standard Operating Procedures for each monitoring component. The Standard Operating Procedures provide detailed methodologies such that the performance monitoring can be carried out consistently over the years of monitoring.

This report integrates the information from all monitoring components for the 2013 calendar year. In 2010, construction activities began within Phase 1 of the Hanlon Creek Business Park, and construction hascontinued through 2011,2012 and 2013. Construction activities began on Phase 2 lands in 2011 and continued through 2012 and 2013. Construction-phase monitoring began in 2010 following four years of pre-construction monitoring.

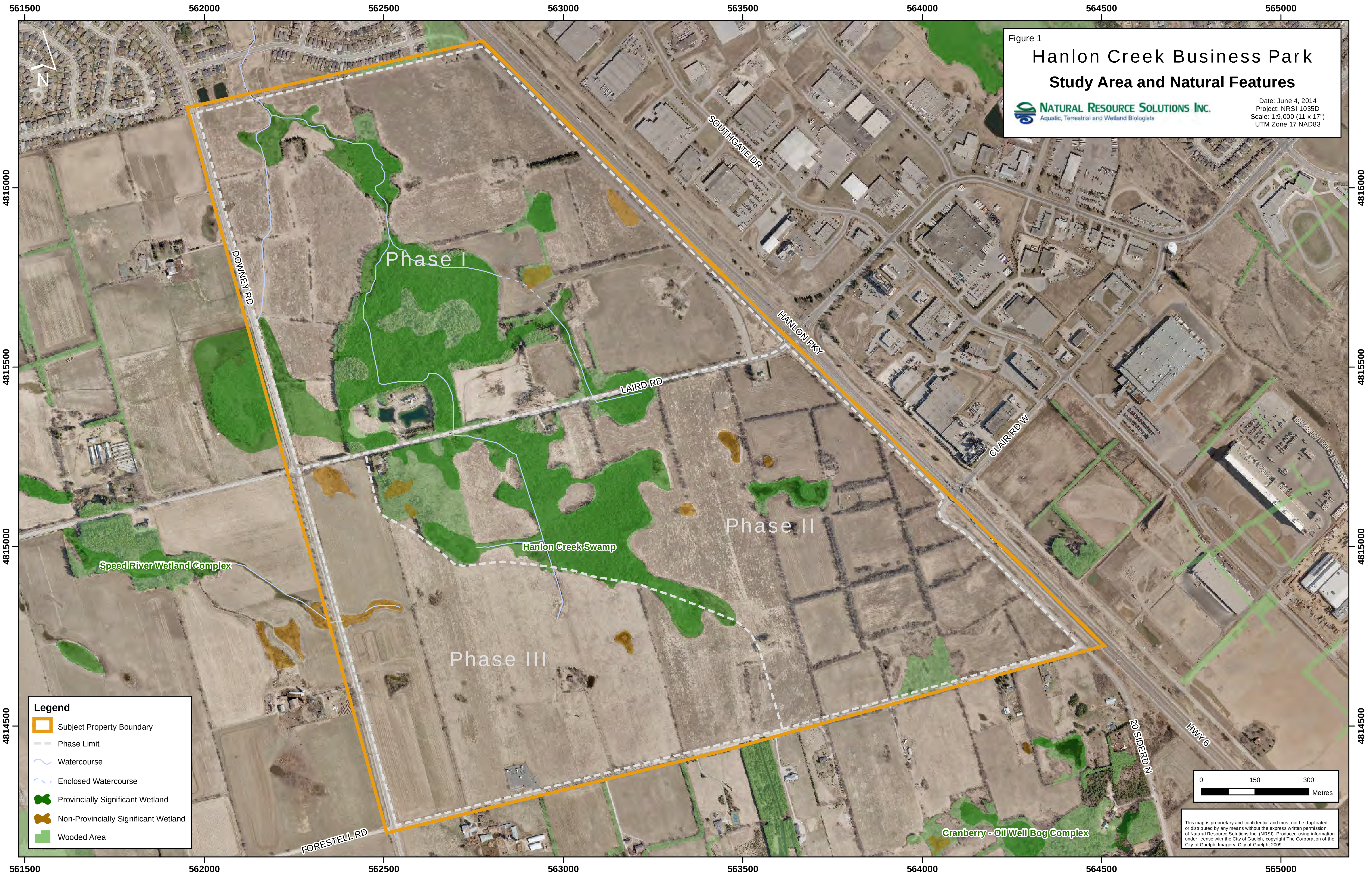
Individual reports from each discipline are appended, and the results are summarized in Section 2.0. Individual reports from past years are listed with the references. The consolidated reporting began in 2009. Natural Resource Solutions Inc. (NRSI) has prepared this consolidated reporteach year with support from Banks Groundwater Engineering Limited (groundwater/hydrogeology), and AECOM (surface water).

1.1 Study Area

In 1993, The City annexed 1,489 ha of land along its southern boundary with the Township of Puslinch (Figure 1). A portion of this land was then designated by the City as Corporate Business Park and Industrial lands (called the 'Hanlon Creek Business Park'). The study area for this project is comprised of the lands between Downey Road and the Hanlon Expressway, and between Forestell Road and the south end of the Kortright subdivision along Teal Drive. The lands fall within Part Lots 16, 17, 18, 19, and 20 Concession 4 and Part Lots 16, 17, 18 and 19 Concession 5 in the former Geographic Township of Puslinch (now the City). Prior to development, lands within Phases 1 and 2 were a mix of agricultural fields, meadow, woodland, forest and Provincially Significant Wetlands (PSW) consisting of swamp, marsh and thicket, while Phase 3 was primarily agricultural field and cultural meadow, with small wetlands. The core area of natural features was designated as natural heritage lands to be retained in their pre-development state. The agricultural fields and associated hedgerows, and small isolated habitats were designated for roads and development blocks.

The creek, wetlands and forested uplands in the HCBP are part of the much larger Hanlon Creek watershed. The central wetlands in the HCBP are part of the Hanlon Swamp Wetland Complex and therefore are considered provincially significant. In addition, a small wetland in the southwestern portion of the HCBP, next to Downey Road, is part of the provincially significant Speed River Wetland Complex.

This area encompasses a headwater tributary of Hanlon Creek. The tributary within the HCBP was designated as Tributary A in the Hanlon Creek Watershed Study (Marshall Macklin Monaghan Limited 1993). All of Hanlon Creek is designated as a cold-water stream to be managed for brook trout (*Salvelinusfontinalis*) (GRCA and MNR 1998).



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1.1.1 Construction Activity

Construction commenced in late 2009 and has continued each year through to 2013. Construction activity in 2013 within Phases 1 and 2 is outlined below and highlighted on Figure 2.

Phase 1

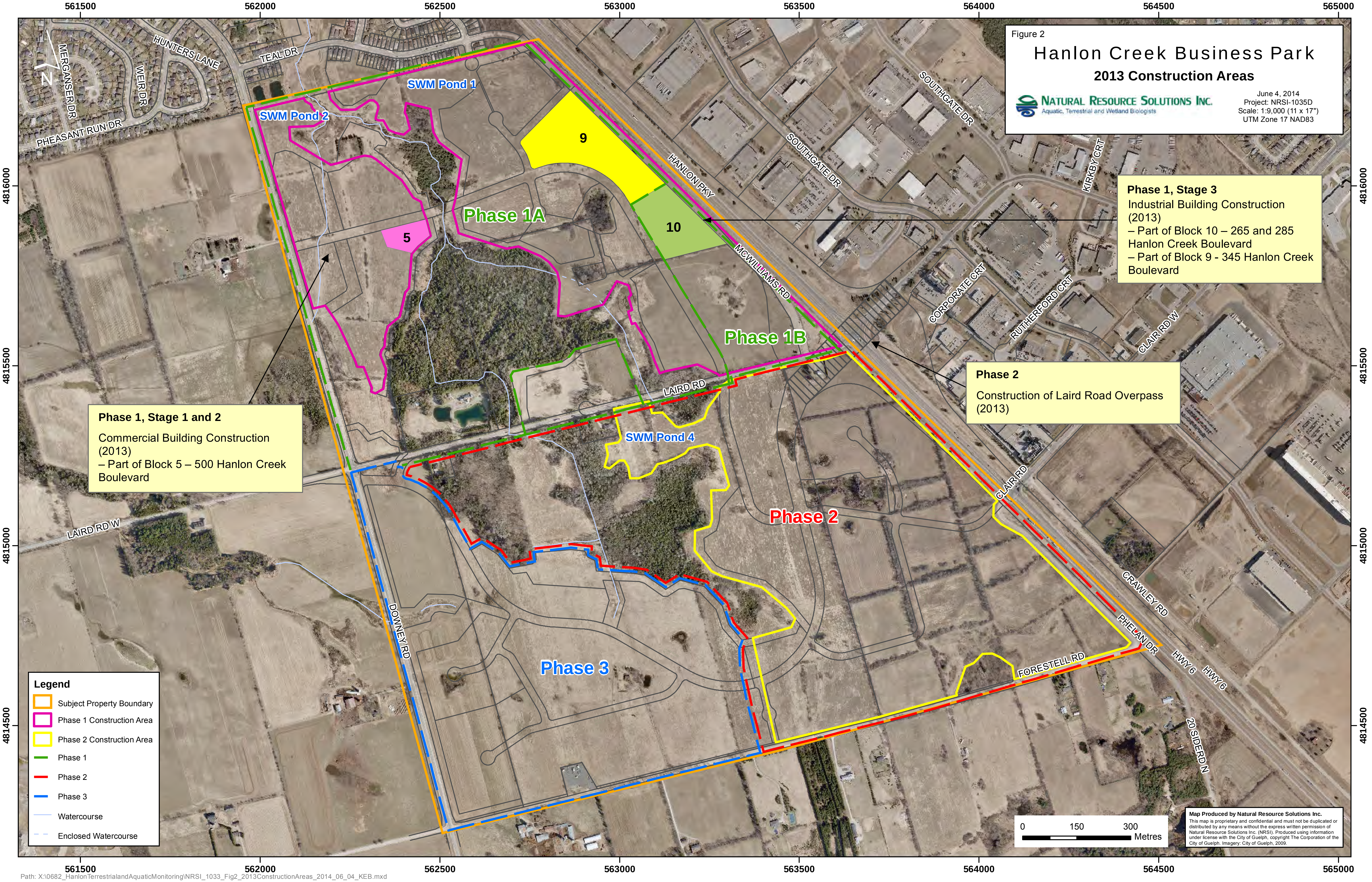
- Operation ofcommercial building l – Part of Block 5 – 500 Hanlon Creek Boulevard
- Construction of industrial building – Part of Block 9 – 345 Hanlon Creek Boulevard
- Construction and operation of industrial building – Part of Block 10 – 265 & 285 Hanlon Creek Boulevard

Phase 2

- Construction of Laird Road overpass by the Ontario Ministry of Transportation (MTO)

Phase 3

- No construction activity occurred within Phase 3 in 2013.



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1.2 Monitoring Requirements and Components

A total of seven discrete monitoring requirements were identifiedduring the planning process for the HCBP. The requirements are each rooted in one or more of the various stages of the process, including the Consolidated EIS (NRSI 2004), the Draft Plan Conditions (OMB 2006), the Environmental Implementation Report, and review comments from agencies pertaining to the design, mitigation and restoration of features in the Business Park.

Theseven discrete monitoring requirements are as follows:

1. **Performance of Stormwater Management Systems:** Monitoring of hydrogeology, creek flows and temperatures, aquatic biota and wetlands, arising from the Draft Plan Condition #12 to provide baseline information on interactions and as input to the design of stormwater management facilities that discharge to Tributary A, as well as post construction monitoring of performance of the ponds (especially thermal impacts).
2. **Groundwater and Wetlands for the HCBP:** Monitoring arising from the Draft Plan Condition #12 of hydrogeology and wetlands at strategic locations to provide baseline information on spatial distribution and interactions of groundwater/wetlands such that block-level infiltration targets can be assessed.
3. **Groundwater and Wetlands for the Mast-Snyder Gravel Pit:** Monitoring of hydrogeology and wetlands in the western portion of lands south of Laird Road (Speed River PSW) to monitor changes in groundwater and wetlands stemming from concerns over potential impacts of the proposed neighbouring Mast-Snyder Gravel Pit.
4. **Permit Conditions and EIR Recommendations:** Monitoring arising as conditions from permit applications/review as well as impact predictions specifically arising from recommendations out of the EIR process.
5. **Success and Naturalization of Restoration Areas:** Monitoring of success and naturalization processes of restoration areas within buffers, swales and stormwater management areas, arising from agency comments and restoration planting warranty.
6. **Wildlife Movement:** Monitoring of wildlife movement throughout the Business Park, with a focus on movement and mortality associated with Laird Road and Hanlon Creek Boulevard (Road ‘A’).
7. **Construction Monitoring:** Monitoring arising from the Draft Plan Condition #10, which states that an environmental inspector is to carry out the construction monitoring during grading, servicing, and building construction.

There are eight performance monitoring components and two construction monitoring components that occur on the HCBP property, and they are being conducted to serve one or more of the requirements listed above. Pre-construction performance monitoring occurred over a number of years to establish baseline conditions. Most of the monitoring activities have been in effect annually beginning in 2006. Groundwater monitoring began in 1999. Some construction inspection occurred in 2009 associated with the Road ‘A’ culvertdirectional service installation under the Hanlon Expressway, and borrow pit operations in the southeast corner of the Business Park. In 2010, construction-phase monitoring began which included the monitoring of grading and servicing construction activities.

The City, as the developer representative, is responsible for this monitoring. The duration of the responsibility to monitor has been defined for each of Phases 1 and 2 as the time when 75% of the area of the individual phase is built, plus an additional two years. It is anticipated that this timeframe will also apply to Phase 3.

1.2.1 Performance Monitoring

The performance monitoring components are indicated as follows, with the past years of monitoring indicated in parentheses.

- Groundwater (most years from 1999 to 2013)
- Stream Temperature and Flow (annually from 2006 to 2013)
- Fish (annually from 2006 to 2013)
- Benthic Invertebrates (annually from 2006 to 2013)
- Vegetation and Soils (annually from 2006 to 2013)
- Breeding Birds (annually from 2006 to 2013)
- Amphibians (annually from 2006 to 2013)
- Salamanders (2009 and 2010 only)

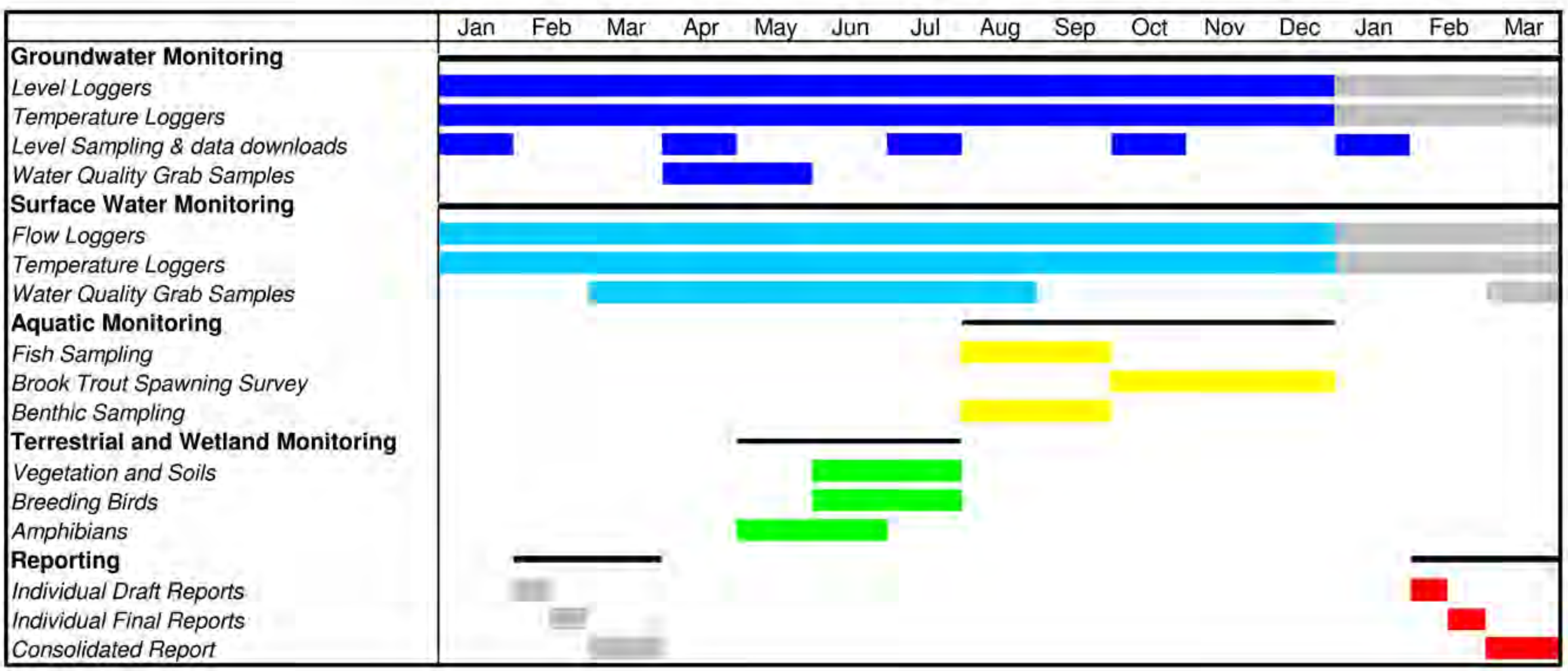
1.2.2 Construction Monitoring

Construction monitoring is tied to the specific undertaking. Generally, construction monitoring must occur to ensure compliance with the conditions of various permits, including permit(s) from the Grand River Conservation Authority (GRCA) under Ontario Regulation 150/06 and the Letter of Advice from GRCA that constitutes approval under Section 35 of the *Fisheries Act*. Construction monitoring also serves as a means to avoid contravention of other regulations, such as Section 36 of the federal *Fisheries Act* pertaining to deleterious substances. In the specific case of the HCBP, the need for construction monitoring also stems from Condition 10 from the OMB hearing for the HCBP Draft Plan (June 2006). The condition states that an environmental inspector is to carry out the construction monitoring during grading, servicing, and building construction.

1.3 Annual Schedule of Activities

Table 1 provides the general annual timeline of performance monitoring activities, which approximates the schedule of the 2013 monitoring. The specific dates of monitoring activities in 2013 are provided in the appended individual reports. Each colour represents an individual monitoring component (Groundwater Monitoring – dark blue, Surface Water Monitoring – light blue, Aquatic Monitoring – yellow, Terrestrial and Wetland Monitoring – green). The timeline for Reporting is represented by red.

Table 1. General Annual Schedule of Performance Monitoring Activities



2.0 Monitoring Results

Several climatic factors influenced groundwater and surface water levels across the Hanlon Creek Business Park. The following is noted for January through December 2013:

- It is interpreted that the combined snowfall and rain through January was equivalent to over 80 mm of precipitation, which is above the normal of 65 mm for this month.
- By comparison, the interpreted combined snowfall and rain through February and March was equivalent to less than 74 mm of precipitation, which is well below the normal of 116 mm for these two months combined.
- Spring thaw began in late-March, with above-freezing maximum daily temperatures continuing into the spring. Following about 19 mm of precipitation during the second week of March, there was almost no precipitation (i.e. 5.4 mm) from mid-March to the end of the first week of April.
- Total rainfall from the second week of April through to the end of the month was about 98 mm, compared to a normal of about 75 mm. May precipitation was below the normal of 82 mm . But June and July precipitation was above the combined normal of 181 mm, with a total of almost 260 mm over the two months. September precipitation was below the 88 mm normal, but October precipitation was more than double the normal of 67 mm, for a combined rainfall of almost 215 mm for the two months.
- November and December precipitation totals were almost half the normal combined amount. However, precipitation from 19 to 22 December totalled about 40 mm, during which time there was an ice storm that affected much of southern Ontario and eastern Canada.
- Total precipitation was above-normal for the months of January, April, June, July, and October. Total monthly precipitation was below normal amounts for the other seven months.
- There were numerous days when the maximum daily temperatures was above freezing during January is interpreted to have resulted in melting of the snow pack, and when combined with rainfall events, increased the potential for groundwater recharge. Groundwater levels increased above the fall 2012 levels.
- Maximum daily air temperatures remained above 0°C for most days from late-March to late-November 2013.
- The total precipitation through 2013 was about 939 mm, as compared to a 43-year average of about 884 mm.
- Based on the monthly ambient air temperatures for the months between May and September, 2013 air temperature daily averages ranged from 13.5 to

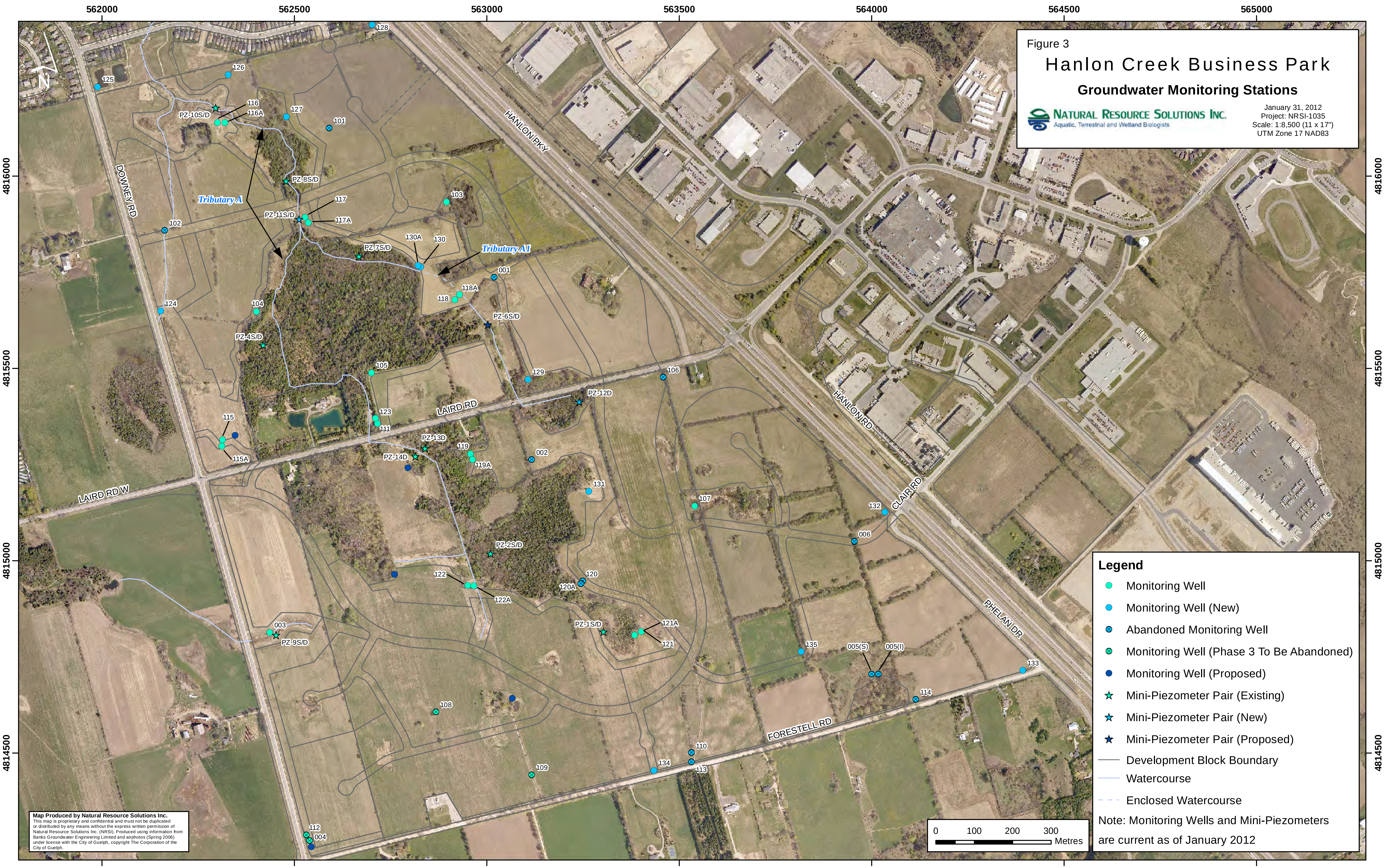
20.4°C, the average daily maximums ranged from 20.2 to 25.3°C, and the average daily minimums ranged from 6.2 to 14.5°C.

Climate data provided by the Region of Waterloo International Airport Station (WMO ID 71368) was utilized for groundwater monitoring due to its proximity to the HCBP site and availability of total daily precipitation maximum daily air temperature data. For comparison of surface water monitoring data, climate information was used from the Guelph Turfgrass Institute and the Elora Research Station, provided by the University of Guelph.

2.1 Groundwater Levels and Flow

At the start of the 2013 monitoring periodthere were 37 functioning monitoring wells and 17 mini-piezometers located across the HCBP site. Two additional mini-piezometers were installed in June on a temporary basis to provide additional monitoring data related to the effects of stormwater management (SWM)Pond 4 on Tributary A.These two monitors remained in place at the end of 2013. To evaluate the response to spring thaw and precipitation at selected groundwater monitors, data loggers were installed to record groundwater levels on a more frequent basis, with installation at some stations beginning in 2007. In the year 2013, groundwater elevations were recorded using data loggers in 38 monitoring stations. Table 1 in the groundwater technical memorandum prepared by Banks Groundwater Engineering Limited (Appendix II) lists the monitoring wells and mini-piezometers where the 38 data loggers were in operation for all or part of 2013. In addition, groundwater quality samples were collected from a total of 34monitoring wells that were available for sampling in 2013. These were the same wells that were sampled in 2012, with the exception of MW123. The locations of all existing groundwater monitoring stations are shown in Figure 3, as of December 2013.

The resulting groundwater level monitoring data is tabulated and plotted on graphs in the appendices of the groundwater technical memorandum prepared by Banks Groundwater Engineering Limited (Appendix II). Those results are summarized and discussed below.



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Groundwater levels were notably high in 2013 compared to results from 2012, which saw levels at the highest recorded since monitoring began in 2003 at many of the monitoring locations. The high groundwater levels experienced in 2013 were attributed to a number of factors. During 2013, maximum daily temperatures fluctuated from below to above freezing from the beginning of January through March. There was above-average precipitation in January, much of it occurring during a thaw mid-month and during another thaw at the end of January. Although precipitation during February and March was almost half the normal amount of 116 mm, the spring melt combined with above-average precipitation in April caused groundwater levels to rise. Maximum daily temperatures were above freezing from late-March through to late-November, allowing infiltration to occur during this period. While groundwater levels began the typical decline in May, the above-normal precipitation in June and July maintained levels across the site above the low levels observed during the previous summer. Precipitation events in late-September and October caused groundwater levels to rise until early-November.

The analysis of groundwater elevation data from the 38 groundwater monitoring stations throughout 2013continue to exhibitthe downward hydraulic gradients (i.e. groundwater recharge conditions) in the upland portions of the site, and upward hydraulic gradients in the vicinity of, and within, the core wetland complex (i.e. groundwater discharge conditions). Groundwater discharge conditions have also been confirmed at the Downey Road PSW, which is discussed in more detail below. Graphs illustrating groundwater elevations and hydraulic gradients are included, with monitoring stations grouped in seven west-to-east profiles, in the groundwater technical memorandum prepared by Banks Groundwater Engineering Limited (Appendix II).

<u>Core Provincially Significant Wetland</u>

Groundwater levels at Core PSW monitoring stations during 2013 responded to climatic factors described in Section 2.1 of this report. During the months of January, February and March 2013, groundwater levels were within the typical ranges for this time of year. Groundwater levels in most monitors then began declining during April and continued to decline through to late-September. The lowest levels observed in 2013 varied from location to location, but most occurred during September. At almost all locations where data loggers had been in place for more than two years, the 2013 summer levels were above the low levels observed during the drought in the summer of 2012. At many Core

PSW monitoring stations, groundwater levels began to recover during October 2013 in response to the above-average precipitation that occurred during this month. Groundwater levels reached a peak at the start of November and then declined until the rainfall (i.e. ice storm) event later in December caused another increase.

Groundwater levels in the three mini-piezometer monitoring locations in the Core PSW (i.e. from north to south PZ-4D, PZ-2D, and PZ-1D), were below the normal range for most of 2012. During 2013, groundwater levels returned to within the range of previous years.Similarly, groundwater levels recorded in streambed mini-piezometers (i.e. from north to south PZ-10D, PZ-8D, PZ-11D, PZ-7D) were below the level of the creek and the streambed for part, if not most, of 2012. Groundwater levels returned during 2013 to the range observed in previous years, where data is available. Generally, groundwater levels were observed at, or above, the streambed during spring months and reduced levels during late-summer months. An associated reduction in the groundwater discharge conditions was noticed in late summer months as groundwater levels decreased to near or slightly below ground level.

Downey Road PSW

Groundwater levels are monitored at two stations at the Downey Road PSW. These include monitoring well MW003, which is located on the north edge of the PSW, and mini-piezometer nest PZ-9, which is located in the centre of the PSW.

Groundwater levels at the Downey Road PSW monitoring stations during 2013 responded to climatic factors similar to the Core PSW monitors. During the months of January, February and March 2013, groundwater levels were within the typical range for this time of year, fluctuating in direct response to maximum daily temperatures above 0°C and corresponding periods of infiltrating precipitation. As noted previously, the combined snowfall and rain through January was equivalent to over 80 mm of precipitation, which is above-normal for this month. These events, combined with events in the second week of March and spring thaw in late-March caused groundwater levels to rise to the highest elevations recorded in 2013. Groundwater levels began a gradual decline in mid-April, with occasional short-duration increases in response to precipitation events measuring more than 15 mm in a 24-hour period. Groundwater levels rose from the third week in September to the second week of November in response to numerous rainfall events. Levels then declined until the rainfall (i.e. ice storm) event later in December caused another increase.

Responses to precipitation and temperature are apparent in PZ-9D, similar to MW003, confirming the infiltrative capacity of the medium- to coarse-grained deposits on this site and the inherent relationship of the wetlands to the shallow groundwater system.

Perimeter Location Monitoring

The responses to precipitation and maximum daily air temperatures are also apparent in these plots. Groundwater elevations vary more widely over the year at perimeter locations in comparison to the Core PSW locations. The perimeter groundwater monitoring stations responded to the above-average precipitation during January, April, June, July, and October 2013, similar to the monitoring stations in the core PSW and the Downey Road PSW.

Climate had the greatest, if not only, influence on groundwater elevations across the HCBP in 2013. There were no apparent short-term and/or longer-term changes in groundwater levels that could be attributed to construction activities during 2013 within the HCBP. There were no abnormal changes in groundwater elevations that would have suggested otherwise.

As described in the 2012 consolidated monitoring report, groundwater elevations across the HCBP were affected by the lack of precipitation in 2012. However, above-normal monthly precipitation in October 2012, and also in January and April 2013, combined with the spring melt, caused groundwater levels to rise across the HCBP. Above-normal precipitation experienced through June, July, and October helped to maintain groundwater levels within the normal range throughout 2013 at all monitoring stations.

2.2 Surface Water Levels and Flow

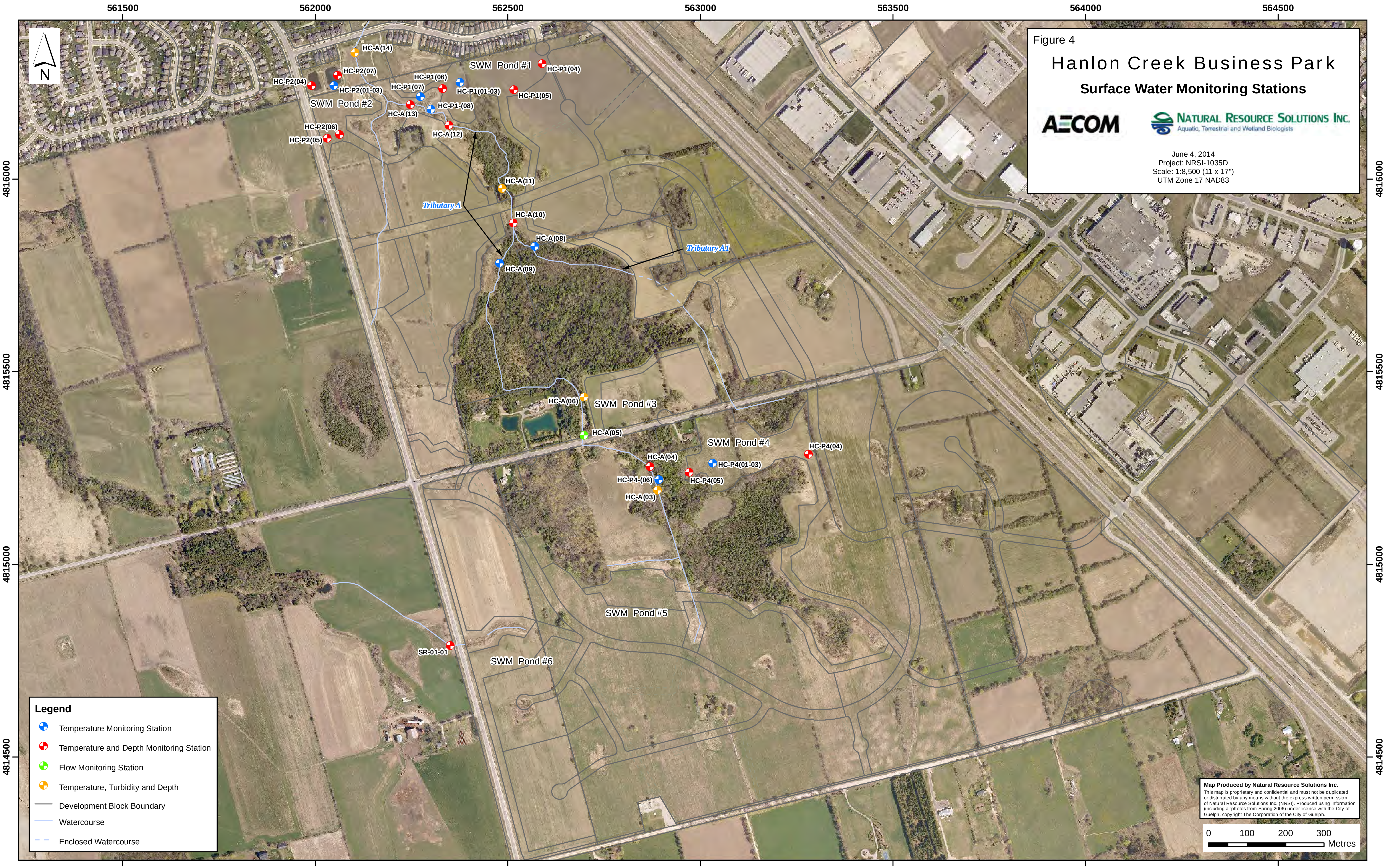
As part of the surface water monitoring program in 2013 continuous flow monitoring was conducted at the same 12 monitoring stations (HC-A(03), HC-A(04), HC-A(05), HC-A(06), HC-A(08), HC-A(09), HC-A(10), HC-A(11), HC-A(12), HC-A(13), HC-A(14), SR-1(01)) along Tributary A and Tributary A1 of Hanlon Creek that were monitored in

2012.Water depth (level) was measured at nine stations, and flow rating curves were developed to provide continuous flow data. In addition to the continuous flow monitoring, baseflow measurements were taken at nine stations between April 20 and November 11, 2013. The resultingsurface water data is presented in the tables and figuresin the surface water monitoring report prepared by AECOM(Appendix III). Those results are summarized and discussed below.

As per GRCA requirements, monitoring was also completed at each of the stormwater management facilities, which included SWM ponds 1, 2, and 4. Monitoring of these locations included three components: inflow and discharge flow rates, water temperature, and water quality sampling. Inflow and discharge are discussed below while water temperature and water quality are discussed in Sections 2.3 and 2.4, respectively. Inflow and discharge flow rates were computed based on water level loggers placed in each facility's inlet and outlet structures. The locations of loggers within each SWM Pond are provided in Table 2. Refer to Figure 4 for all monitoring station locations.

Table 2.Stormwater Management Pond Monitoring Stations

Station	Data Collected	Date installed	Location
Pond 1			
HC-P1(01)	Temperature	September 2011	In pond close to bottom
HC-P1(02)	Temperature	September 2011	In pond near mid-depth
HC-P1(03)	Temperature	September 2011	In pond at surface
HC-P1(04)	Temperature, Depth	September 2011	Inlet
HC-P1(05)	Temperature, Depth	September 2011	Inlet
HC-P1(06)	Temperature, Depth	June 2011	Outlet
HC-P1(07)	Temperature	June 2011	Cooling trench outlet
HC-P1(08)	Temperature	June 2011	Cooling trench outlet
Pond 2			
HC-P2(01)	Temperature	April 2011	In pond close to bottom
HC-P2(02)	Temperature	April 2011	In pond near mid-depth
HC-P2(03)	Temperature	April 2011	In pond at surface
HC-P2(04)	Temperature, Depth	April 2011	Inlet
HC-P2(05)	Temperature, Depth	August 2012	Inlet
HC-P2(06)	Temperature, Depth	June 2011	Inlet
HC-P2(07)	Temperature, Depth	April 2011	Outlet
Pond 4			
HC-P4(01)	Temperature	October 2011	In pond close to bottom
HC-P4(02)	Temperature	November 2011	In pond near mid-depth
HC-P4(03)	Temperature	November 2011	In pond at surface
HC-P4(04)	Temperature, Depth	August 2012	Inlet
HC-P4(05)	Temperature, Depth	October 2011	Outlet
HC-P4(06)	Temperature	October 2011	Cooling trench outlet



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Operational issues were experienced throughout 2013 at several surface water monitoring stations. These issues included flow depthsthat were less than the measurable threshold of the equipment; equipment malfunction; poor correlation for stage discharge relationships due to elevated turbidity levels;excessive growth of instream vegetation; and inundation of stream channel during high flow events. Issues are described in greater detail in the surface water monitoring report prepared by AECOM (Appendix III).

Overall, 2013 experienced higher average precipitation levels than the previous year, 885.8 mm compared to 716.2 mm in 2012, but because of a small number of months receiving very little precipitation it can be concluded that the precipitation levels experienced in 2013 were about average as compared to the Canadian Climate Normals (923.3 mm). Higher precipitation levels contributed to increased baseflow measurements as eight out of the 10 stations recorded greater baseflow averages than 2012. Only stations HC-A(11) and HC-A(13) experienced average baseflows lower than those observed in 2012. Unlike 2012, no period of intermittent flow was recorded in 2013. A plot showing the creek flow at six surface water stations as well as precipitation data collected at the Guelph Turfgrass Institute for the 2013 monitoring period is shown in Figure 5.Baseflow measurements for 2013 are shown in Figure 6, and a summary of baseflow monitoring from 2008 to 2013 is provided in Table 3.

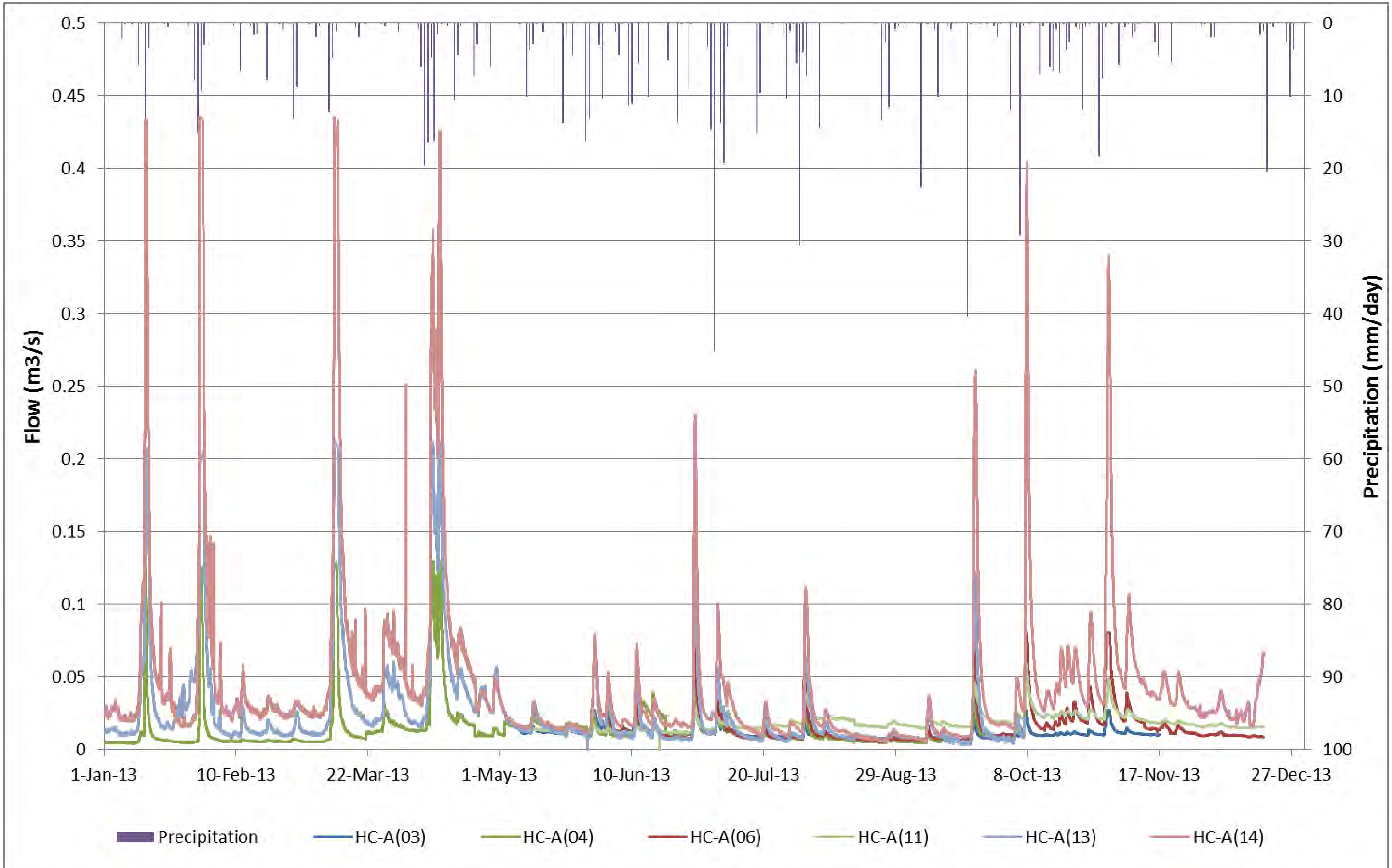


Figure 5.Tributary A and A1 Flow and Precipitation Monitoring – Continuous for Six Stations, January 2012 to December 2013

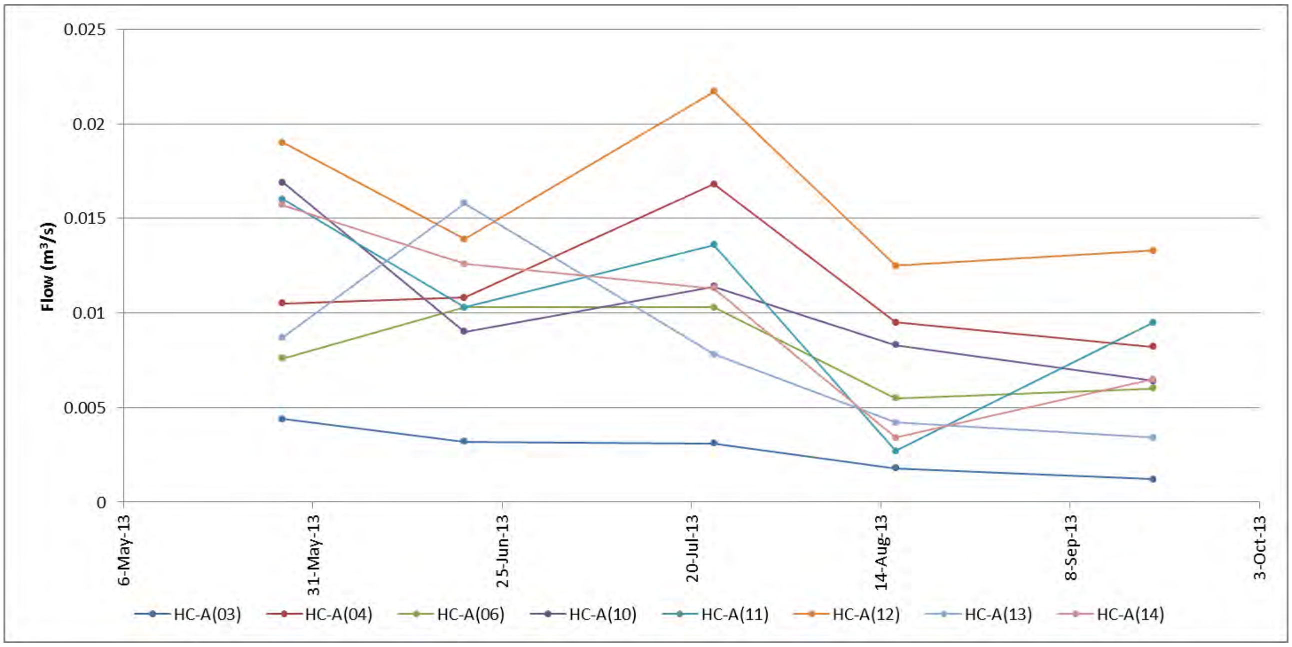


Figure 6.2013 Hanlon Creek Tributary A Baseflow Measurements

Table 3. Hanlon CreekBaseflow Monitoring – 2008 to 2013 Summary (m^3/s)

Station	HC-A(03)	HC-A(04)	HC-A(06)	HC-A(08) Tributary	HC-A(09)	HC-A(10)	HC-A(11)	HC-A(12)	HC-A(13)	HC-A(14)
2008 Min	n/a	0.0035	0.0027	0.0021	0.0038	0.0077	n/a	n/a	n/a	0.0009
2009 Min	n/a	0.0039	0.0012	0.0030	0.0042	0.0050	n/a	n/a	n/a	0.0018
2010 Min	n/a	0.0004	0.0004	-0.0073	0.0011	0.0008	n/a	n/a	n/a	0.0009
2011 Min[2]	0.0028	0.0055	0.0008	0.0015	n/a	0.0024	0.0046	0.0050	0.0028	0.0015
2012 Min	0.0001[1]	0.0032	0.0031	0.0005	n/a	0.0013	0.0007	0.0017[1]	0.0006[1]	0.0007[1]
2013 Min	0.0012	0.0082	0.0055	n/a	n/a	0.0064	0.0027	0.0125	0.0034	0.0034
2008 Max	n/a	0.0113	0.0107	0.0100	0.0094	0.0168	n/a	n/a	n/a	0.0121
2009 Max	n/a	0.0149	0.0256	0.0221	0.0187	0.0563	n/a	n/a	n/a	0.0538
2010 Max	n/a	0.0029	0.0049	0.0123	0.0067	0.0222	n/a	n/a	n/a	0.0112
2011 Max[2]	0.0474	0.0566	0.0500	0.0059	n/a	0.0315	0.0460	0.0319	0.0482	0.0480
2012 Max	0.0025	0.0105	0.0146	0.0074	n/a	0.0132	0.0456	0.0176	0.0366	0.0207
2013 Max	0.0044	0.0168	0.0103	n/a	n/a	0.0169	0.016	0.0217	0.0158	0.0157
2008 Average	n/a	0.0060	0.0093	0.0090	0.0085	0.0205	n/a	n/a	n/a	0.0158
2009 Average	n/a	0.0078	0.0107	0.0093	0.0106	0.0213	n/a	n/a	n/a	0.0197
2010 Average	n/a	0.0016	0.0020	0.0024	0.0036	0.0071	n/a	n/a	n/a	0.0050
2011 Average[2]	0.0146	0.0217	0.0202	0.0027	n/a	0.0193	0.0206	0.0180	0.0205	0.0172
2012 Average	0.0011	0.0061	0.0075	0.0031	n/a	0.0080	0.0144	0.0106	0.0109	0.0091
2013 Average	0.0027	0.0112	0.0079	n/a	n/a	0.0104	0.0104	0.0161	0.0080	0.0099
Notes	[1] Hanlon Creek was noted to be dry or flows were below the measurement threshold flow at stations HC-A(03),HC-A(12), HC-A(13) and HC-A(14) [2] Baseflows were influenced by construction activities									

Recorded baseflow discharge from HC-A(03) was slightly higher in 2013 than 2012 but much lower in 2013 in comparison to 2011 when pumped water from SWM Pond 4 was making its way to Tributary A, upstream of this station as reported in the 2011 and 2012 Comprehensive Monitoring Reports. Although measures were taken to reduce the outflow from Pond 4 in 2012, pond discharge was still observed to be near continuous causing high baseflow levels at HC-A(04) through 2013. Increased baseflow levels at station HC-A(04) transformed the reach between HC-A(04) and HC-A(06) into a losing reach (where surface water infiltrates into the ground) in 2013. The reach between HC-A(09) and HC-A(10) receives input from groundwater-fed Tributary A1 within the cedar swamp, which helped it remain a gaining reach. HC-A(10) and HC-A(11) have historically been groundwater discharge areas and this was the case for 2013. HC-A(12), HC-A(13) and HC-A(14) were all areas of ground water recharge or losing reaches in 2013.

2.3 Water Temperature

Groundwater

Groundwater temperatures were recorded using data loggers in 38 groundwater monitoring stations across the Hanlon Creek Business Park.Temperature monitoring has been conducted since 2007 at four PSW monitoring locations (MW003, PZ-9D, PZ-2D, and PZ-7D),all of which are representative of shallow groundwater conditions within the site. The groundwater temperature results are given in the 2013 technical memorandum prepared by Banks Groundwater Engineering (Appendix I) and discussed as follows.

Temperature ranges for each location were as follows:

- MW003 – similar to previous years ranging from a low of 6°C in late-March to a high of 12°C in late-October
- PZ-9D – ranged from a low of 3°C in late-March to a high of almost 15°C in early-September
- PZ-2D – ranged from a low of 4°C in mid-April to a high in early-September of almost 13°C
- PZ-7D – ranged from a low of 5°C in late-March to a high of 11°C in late-August.

The temperature range of groundwater at greater depths in this general area tends to fluctuate in a narrower range, typically between 5 and 10°C. It is therefore apparent that the temperatures in the shallower groundwater regime in the vicinity of these four monitors are influenced by seasonal variations in air temperature and solar radiation. These data are interpreted to be representative of the temperature of groundwater discharging to the wetlands and creeks in these locations.

Monitoring well MW119A is located adjacent to and down-gradient from SWM Pond 4. Groundwater temperatures recorded in monitoring well MW119A during 2013 ranged from a low of 5°C at the start of April, to a high of about 16°C in mid-September. This is comparable to the ranges observed from 2008 to 2011. The high temperature of 16°C in 2013 was below the highest temperature recorded, which was 17.5°C on September 5, 2012.Prior to construction of SWM Pond 4 in late 2010, the highest groundwater temperature at this monitor was 15.0°C in early-September 2010. Prior to that, the years 2008 and 2009 had reached a maximum of approximately 13°C in September. At the end of December 2012, the groundwater temperature at monitoring well MW119A was 10.0°C, compared to about 7.0 to 8.0°C on the same date the preceding four years. In late December 2013, the temperature at this monitoring well was close to 9.5°C.

The bottom of SWM Pond 4 is below the shallow groundwater surface and as a result the un-lined pond is in direct contact with the local groundwater system. A portion of the water in the pond is interpreted to discharge from the pond as groundwater in a north-westerly direction, flowing into the ground adjacent to the pond. Therefore, water in the pond warmed by solar radiation during summer months of 2013appears to continue to increase the groundwater temperature marginally in the area down-gradient (north-west) of the pond.Additional monitoring of groundwater temperatures down-gradient of SWM Pond 4 was initiated in June 2013. A pair of shallow mini-piezometers (PZ-13 and PZ-14) were installed on the east and west bank of Tributary 'A', and equipped with data loggers. The piezometers were located a short distance down-stream from surface water monitoring station HC-A(04). Based on results from these monitoring stations it is apparent that the groundwater temperature at PZ-13D and PZ-14D, which reached a maximum of just less than 14^{0}C in early September, was possibly influenced by the warmer shallow groundwater flow affected by Pond 4. However, groundwater temperatures at these locations returned to normal seasonal temperatures (approximately 6 to 8^0C) by the end of 2013. This issue is discussed further in Section 5.2.2.

Surface Water

Surface water temperatures were measured using data loggers at 11 stream stations and in numerous locations within SWM Ponds 1, 2 and 4. The results are given in the surface water monitoring report prepared by AECOM (Appendix III), and are summarized and discussed as follows.

A plot of the continuous temperature monitoring throughout the year 2013 is provided in Figure 7. Limited data is available for the 2013 winter season due to logger failure and data collection gaps. However, the following observations can be made. During sub-zero air temperatures in the winter months, station HC-09, HC-A(13), and HC-A(14) showed extended periods of little to no variation in temperature and, therefore, were likely frozen. In comparison to previous monitoring records, station HC-A(10) showed the greatest fluctuation in daily temperatures during winter months. Stations HC-A(04), HC-A(06) and HC-A(08) also showed significant fluctuations and HC-A(08) maintained the highest temperatures, generally above 3°C. During summer months the stations which are more exposed such as HC-A(14), HC-A(13), HC-A(12) and HC-A(10); and those with a wider flow channel and shallower depths (HC-A(09)) show the highest daily variation in temperature as there is greater opportunity for solar radiation impact. Station HC-A(08) shows the lowest temperatures and daily temperature variation during the summer, and, combined with the high winter temperatures, indicates the presence of groundwater inputs as noted in previous years.

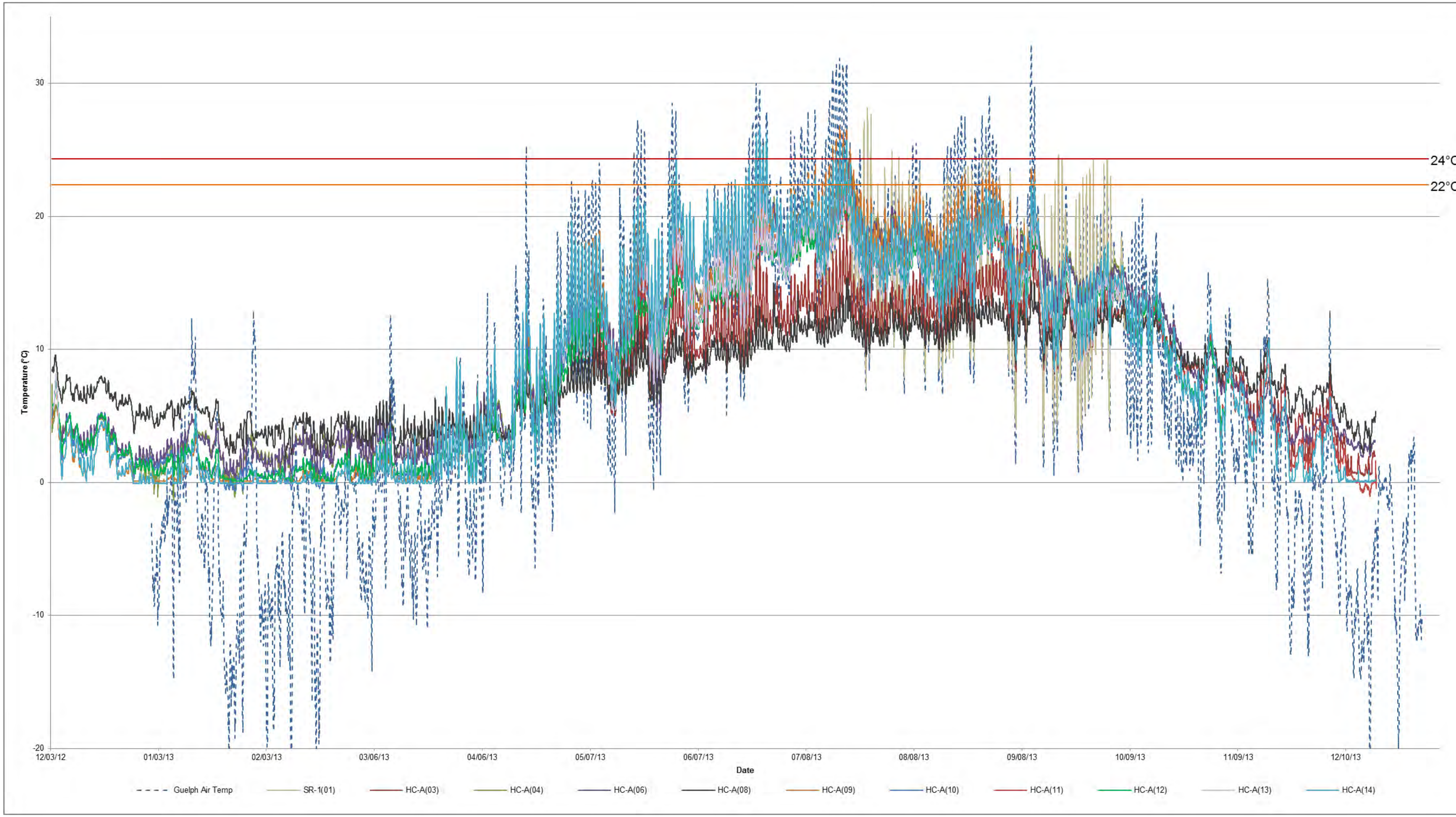


Figure 7. Tributary A and A1 Temperature Monitoring – Continuous Temperature for 11 Stations, January to December 2013

The ability of a stream to support a cold water fish species is often defined by the temperatures through summer (July and August) and autumn (mid-October – end of November) months. In general, water temperatures observed in 2013 were above the ideal habitat conditions documented for brook trout in the *Hanlon Creek Business Park Stream Temperature Impact Report Continuous Modeling with HSP-F* (AECOM, 2009). Toward the management objective of achieving suitable temperatures for brook trout, a coldwater fish species, the Hanlon Creek Business Park Consolidated Monitoring Plan has established the two thresholds to include either a single temperature exceedance of 22.0°C, or any single temperature exceedance of 24.0°C. Elevated temperatures in 2012 resulted in the highest number of exceedances recorded to date. While fewer exceedance events occurred in 2013 compared to 2012,temperatures remained higher at stations found farthest downstream and the trend of increasing temperatures at reaches downstream of Pond 4, observed in 2012, also continued. During 2013, HC-A(04), HC-A(06) and HC-A(09) all saw extended periods above 24°C, caused in part by the continuous discharge from Pond 4. Exceedances were also noted in May of 2013 at HC-A(14). These issues were noted, and the RAAP team was assembled to try to address the cause of the exceedances. These exceedances and the actions taken are discussed in Sections 4.0 and 5.0.

Table 4 shows the thermal regime classifications for Tributaries A and A1 from 2006 to 2013 using the methods developed by Stoneman and Jones (1996) and revised by Chu (2009). The 2013 classifications show overall cooler conditions than in 2012, andcomparableconditions toother previous years. Table 5 provides a summary of the summer temperatures using the continuous temperature monitoring data for Tributaries A and A1, as compared to certain criteria that are of relevance to brook trout temperature requirements. These criteria are described in the 2009 Hanlon Business Park Stream Temperature Impact Report (AECOM, 2009).

Table 4. Temperature Classification Summary

	Based on C. Chu *et al.* (2009)						Based on Stoneman and Jones (1996)	
Station	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**
HC-A(03)	Cool-Cold	Cool	Cool	n/a	n/a	n/a	n/a	n/a
HC-A(04)	Cool-Warm	Warm	Cool	Cool	Cool-Cold	Cool-Cold	Cold	Cold
HC-A(06)	Cool-Warm	Warm	Cool	Cool	Cool-Cold	Cool-Cold	Cool	Cool
HC-A(08)	Cold	Cool-Cold	Cold	Cold	Cold	Cold	Cold	Cold
HC-A(09)	Cool-Warm	Warm	Cool-Warm	Cool-Warm	n/a	Cool	Cold	Cool
HC-A(10)	Cool-Warm	Cool-Warm	Cool-Warm	Cool-Cold	n/a	Cool-Cold	Cool	Cool
HC-A(11)	Cool	Cool-Warm	Cool	Cool	Cool-Warm	Cool	Warm	Warm
HC-A(12)	Cool	Warm	Cool-Warm	n/a	n/a	n/a	n/a	n/a
HC-A(13)	Cool	Warm	Cool-Warm	n/a	n/a	n/a	n/a	n/a
HC-A(14)	Cool-Warm	Warm	Cool-Warm	Cool-Warm	Cool	Cool	n/a	n/a

Table 5.Summer (July to August) Temperature Summary

Station	Modeled Values[1]	HC-A(03)	HC-A(04)	HC-A(06)	HC-A(08)	HC-A(09)	HC-A(10)	HC-A(11)	HC-A(12)	HC-A(13)	HC-A(14)	SR-1(01)
Summer (July-August) average maximum	14.5 - 19.9	15.60	20.5	20.63	18.2	21.8	19.6	19.03	18.9	19.8	20.65	21.8
Summer July-August) average	12.5 - 14.5	13.59	19.6	19.48	16.0	19.2	17.3	17.39	17.3	17.6	18.28	17.4
Summer (July-August) average minimum	9.0 - 12.0	12.02	18.7	18.49	14.4	17.3	15.6	16.10	16.0	15.8	16.24	13.6
Maximum 3-day mean	14.0 - 19.0	16.03	23.2	23.12	20.8	23.5	21.1	20.67	21.5	21.9	22.51	20.5
Maximum 7-day mean	13.0 - 17.0	15.09	22.4	22.29	20.2	22.6	20.3	20.00	20.7	21.1	21.65	19.7
Maximum 7-day mean of daily maximums	15.0 - 23.5	18.05	23.4	23.60	22.4	25.7	23.2	21.69	23.5	24.1	24.66	24.2
	Temperature Exceedance over 19°C for July and August											
Hours over 19°C	0 - 130	5	924	902	393	784	295	264	227	366	579	484
Percent of Time over 19°C	0 - 9%	0%	62%	61%	26%	53%	20%	18%	15%	25%	39%	33%
Frequency of Exceedance over 19°C (Days)	0 - 27	1	55	57	38	59	33	30	26	35	50	56
Average Duration of Event Over 19°C (h)	3 - 6	5.00	27.2	24.39	10.6	16.3	9.5	9.44	9.9	11.4	13.15	7.2
Maximum duration of event over 19°C (h)	<<130	5	267.5	236	44	183.5	64.8	89.8	89	90	114.5	42.3
	Temperature Exceedance over 22°C for July and August											
Hours over 22°C		0	101	99	42	171	36	11	43	62	87	74
Percent of Time over 22°C		0%	7%	7%	3%	12%	2%	1%	3%	4%	6%	5%
Frequency of Exceedance over 22°C (Days)		0	6	7	9	22	6	4	6	9	11	28
Average Duration of Event Over 22°C (h)		0	35.3	23.21	2.7	8.2	3.3	1.77	4.1	4.5	5.15	1.7
Maximum duration of event over 22°C (h)	<<130	0	83	64.3	7.3	39.8	7	3.8	9.3	10.8	13.5	5.5
	Temperature Exceedance over 24°C for July and August											
Hours over 24°C	0 -3.2	0	21	13	0	42	2	0	9	18	27	18
Percent of Time over 24°C	0 - 0.21%	0.00%	1.00%	1.00%	0.00%	3.00%	0.0%	0.0%	1.00%	1.00%	2.00%	1.00%
Frequency of 24°C Exceedance (Days)		0	2	2	0	6	2	0	3	4	5	8
Average Duration of Event Over 24°C (h)		0.0	10.3	6.25	0.0	7.0	1.0	0.0	3.0	4.5	5.35	1.8
Maximum duration of event over 24°C (h)	<3.2	0.0	16.3	7.8	0.0	8.8	1	0.0	3.8	5.5	7.3	4.3

[1]Modeled range referees to the results of the Hanlon Creek Business Park Stream Temperate Impact Report Continuous Modeling with HSP-F (AECOM, 2009)

In addition to the monitoring of stream temperatures, monitoring was conducted at the constructed stormwater management facilities, which included SWM Pond 1, SWM Pond 2, and SWM Pond 4. Temperature was measured at each pond's inlet, atthree depths near the bottom-draw outlet, at the outlet of the pond, and at the outlet of the cooling trench (where applicable). SWM Pond 2 was not discharging to Hanlon Creek during the summer months in 2013 and therefore the results for this pond are not presented in thesurface water report prepared by AECOM (Appendix III) or this consolidated report.

Within SWM Pond 1 and SWM Pond 4, the greatest fluctuations in temperatures were observed at the monitors located at each pond's surface. They generally returned the highest temperatures during the summer months, a result of solar radiation, and the lowest temperatures during the winter months,due to the freezing or near freezing of the pond's surface. In contrast, water temperatures at the bottom of the ponds were typically lower than the surface water during the summer months and higher (approximately 4.0°C) throughout the winter. The temperatures at the bottom-draw outlets were generally lower (during summer months) than the in-pond loggers, demonstrating that the bottom draw outlet successfully allows for the discharge of the coldest (deepest) water first from each pond. Further to this, the water temperatures recorded at the outlet of the cooling trench tended to have the least amount of variation, indicating that the cooling trenches did have a moderating, and generally cooling, effect on the discharged flows into Hanlon Creek. Pond-specific results are discussed below.

SWM Pond 1

SWM Pont 1 experienced little discharge throughout the summer months resulting in the majority of the cooling trench temperature data not representing actual discharge events. However, when a discharge event did occur, it was noted that the southernmost cooling trench (HC-P1(08)) was more effective at lowering temperatures than the cooling trench to the north (HC-P1(07)) (refer to Figure 8). On one particular occasion on July 5, 2014, the water at the outlet of the southern trench to the creek remained at least 2°C lower than the water discharging from the pond into the trench. In comparison, the water temperature at the outlet of the northern trench to the creek, which initially showed a cooling effect, matched and sometimes exceeded the water temperature recorded at the ponds' bottom-draw outlet.This trench is located in a more open area and is more susceptible to solar heating and high temperatures, as some of the rocks in the trench are at ground surface where it is exposed to solar radiation and air temperatures. Overall, it still appears that this cooling trench is an effective means of lowering discharge temperatures.

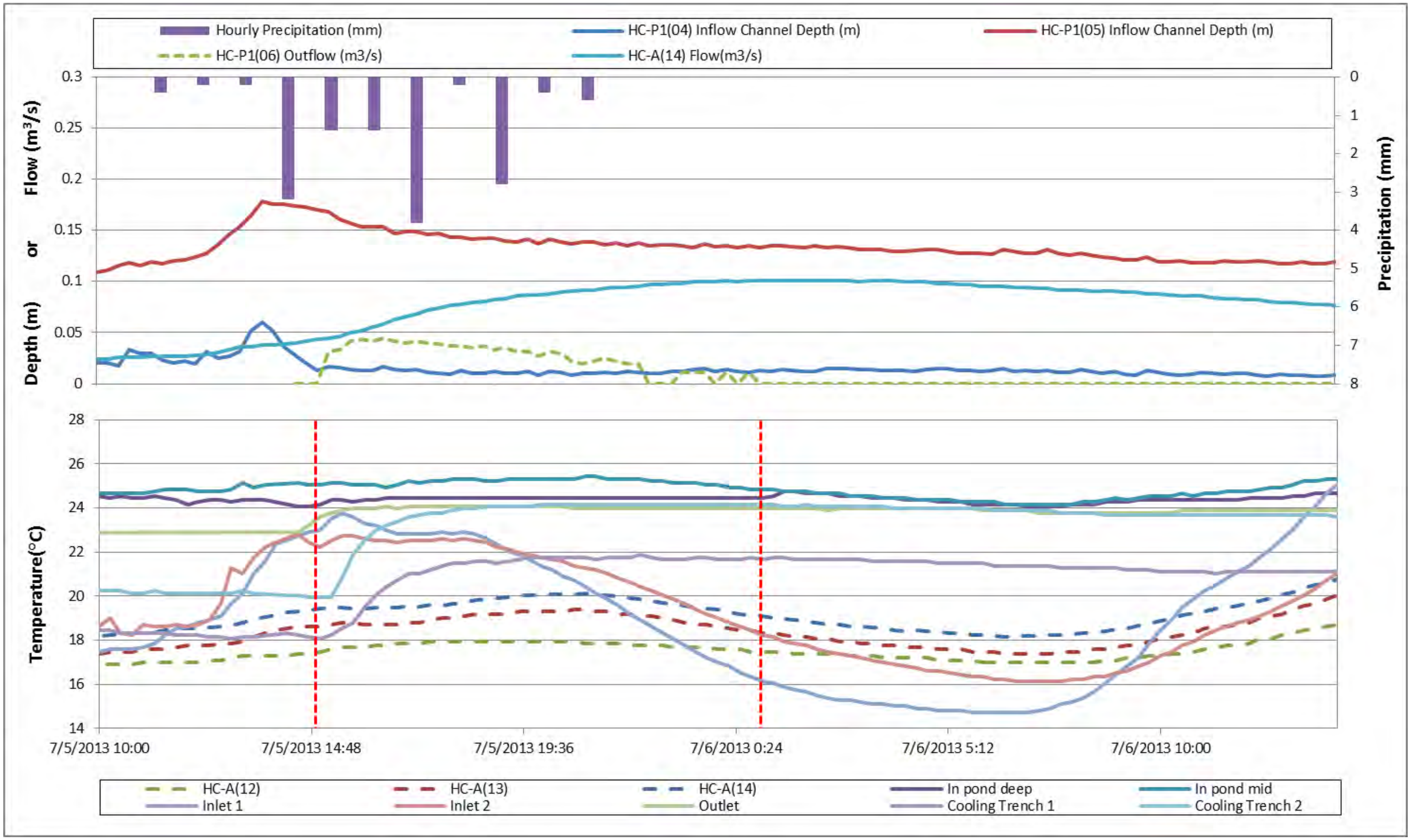


Figure 8.SWM Pond 1: Computed outflow, measured inflow channel depth, and measured temperatures within and exiting pond; precipitation; measured temperatures on Tributary A (HC-A(12)) upstream and downstream (HC-A(13, 14)) of Pond 1.

SWM Pond 4

Similar temperature characteristics to SWM Pond 1 were observed at SWM Pond 4 over the course of the 2013 monitoring season. In addition, the temperature at the bottom-draw outlet was generally lower (during summer months) than the in-pond loggers; it appears that the bottom draw outlet successfully allows for the discharge of the coldest (deepest) water first. Despite the cooling effects of the trench and bottom draw outlet, temperatures leaving the pond were still higher than water temperatures upstream of the outlet of SWM Pond 4. The temperatures recorded downstream of SWM Pond 4 were higher than those recorded upstream of the pond outlet with several temperature threshold exceedances during the summer months. The moderating temperature effect of the cooling trench highlights the pond's temperature impacts immediately downstream of the outlet, which shows a much smaller magnitude of diurnal temperature fluctuations than those observed in the creek sites upstream and further downstream. While the cooling design features at Pond 4 resulted in outflows that were often more than 5°C less than the surface temperatures within the pond, the cooling trench outflows were still typically 3-6°C warmer than the upstream station HC-A(03) within Tributary A (Figures 9 and 10).

In September 2012, aquatic vegetation was planted in the pond and the outlet weir was raised to reduce the constant discharge from SWM Pond 4. Raising the weir height did not stop SWM Pond 4 from continuously discharging in 2013, although it is thought that the discharge is now largely due to groundwater being intercepted by the cooling trench instead of the pond. Additional plantings of vines and other fauna was completed on the cooling trench in an attempt to shade the exposed rock at the end of 2012. Although the plants did not mature sufficiently in 2013to cover the cooling trench, these additional design features are anticipated to provide additional cooling to the ponds discharge in future summer seasons.

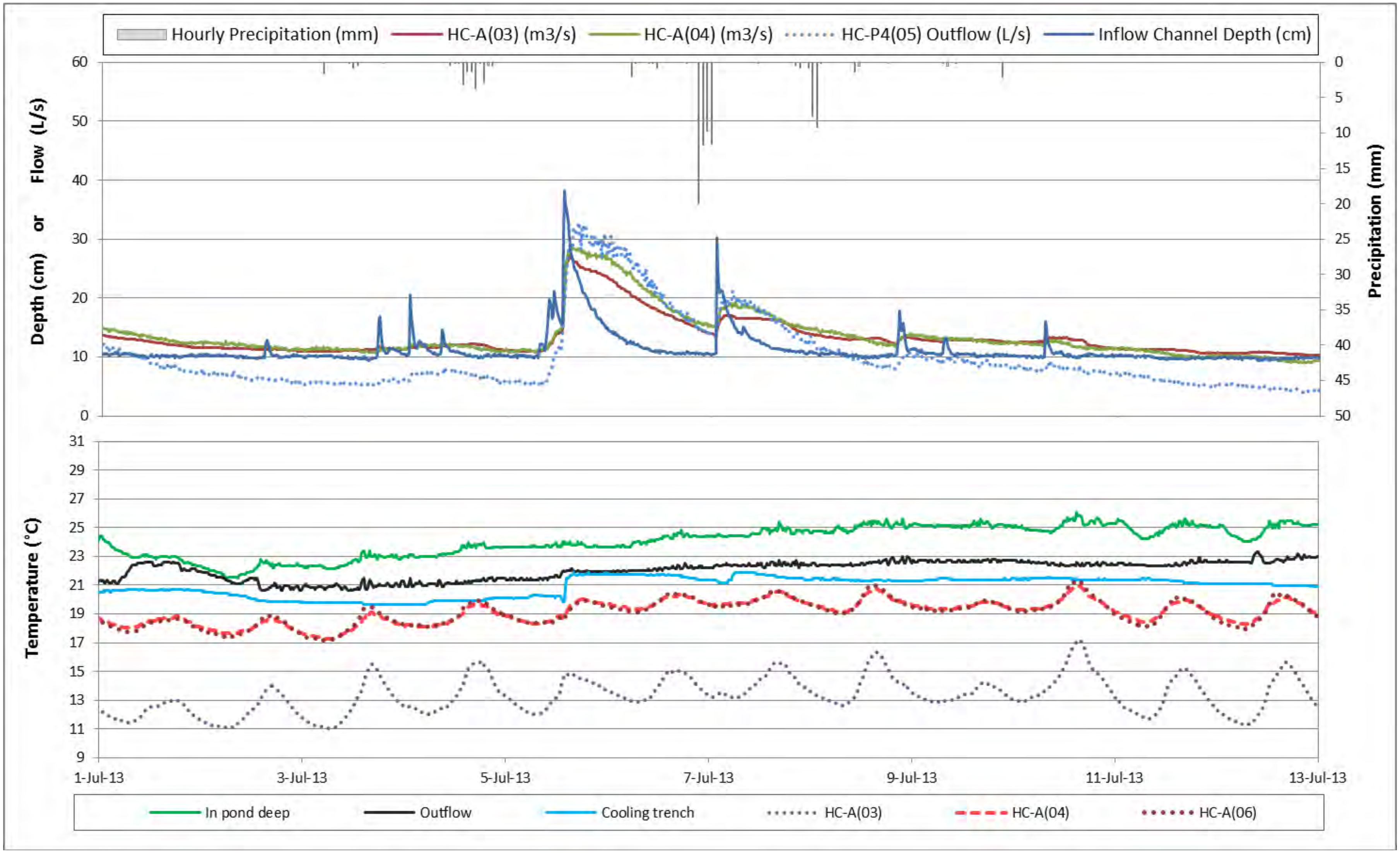


Figure 9.SWM Pond 4: Computed outflow, measured inflow channel depth, and measured temperatures within and exiting pond; precipitation; measured temperatures on Tributary A (HC-A(03)) upstream and downstream (HC-A(04, 06)) of Pond 4 during a wet period.

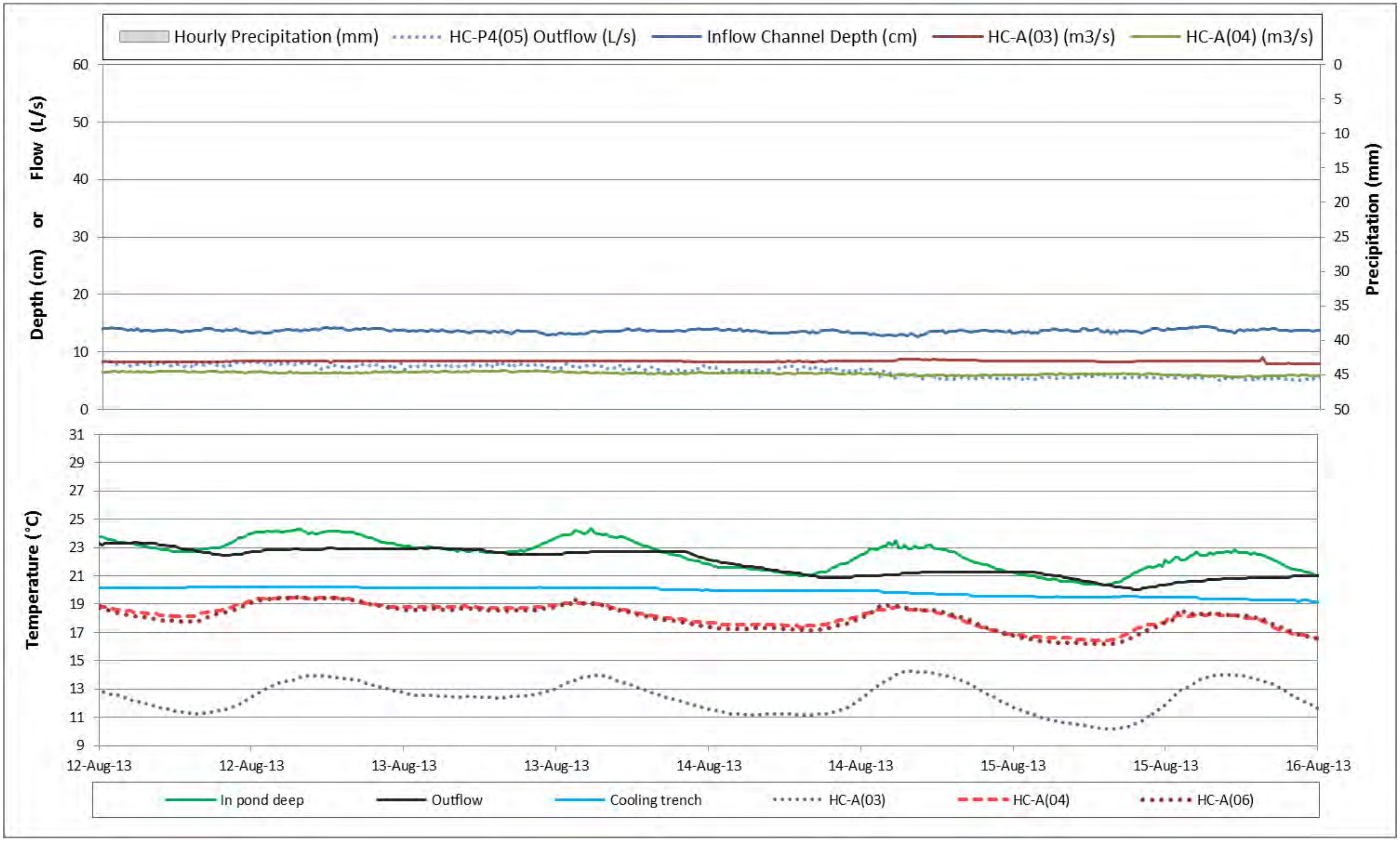


Figure 10.SWM Pond 4: Computed outflow, measured inflow channel depth, and measured temperatures within and exiting pond; precipitation; measured temperatures on Tributary A (HC-A(03)) upstream and downstream (HC-A(04,06)) of Pond 4 during a dry period.

2.4 Water Quality

Groundwater

The groundwater quality results are given in the 2013 technical memorandum prepared by Banks Groundwater Engineering (Appendix I) and discussed as follows. In general, the concentrations of the parameters analyzed were below the applicable ODWQS criteria, with the following exceptions (refer to Appendix I for specific exceedances):

- Nitrate (as N) concentrations exceeded the ODWQS of 10.0 mg/L on at least one occasion in six monitoring wells
- Aluminum concentrations exceeded the ODWQS of 0.1 mg/L on at least one occasion in 24 monitoring wells
- Cadmium concentrations exceeded the ODWQS of 0.005 mg/L on at least one occasion in 11 monitoring wells
- Iron concentrations exceeded the ODWQS of 0.3 mg/L on at least one occasion in 31 monitoring wells
- Lead concentrations exceeded the ODWQS of 0.010 mg/L on at least one occasion in 22 monitoring wells
- Manganese concentrations exceeded the ODWQS of 0.05 mg/L on at least one occasion in 37 monitoring wells
- Sodium concentrations exceeded the ODWQS of 20 mg/L on at least one occasion in 37 monitoring wells
- Hardness concentrations exceeded the ODWQS of 100 mg/L in all monitoring wells.

Colour, turbidity, total dissolved solids, and DOC exceeded the respective ODWQS concentrations in most of the monitoring wells. This observation is typical for monitoring wells that are not developed to a sediment-free condition. Improved filtering of samples at the time of collection since 2009 has resulted in reduced levels of some parameters.

Surface Water

During each field visit a YSI multi-parameter probe (556R) was used to collect dissolved oxygen, pH, and specific conductivity conditions at each stream site. These results for the stream sites are shown graphically in Figures 11, 12 and 13, respectively. Turbidity was measured using sensors at four stations in Tributary A. Grab sample results were taken in SWM Ponds 1, 2 and 4 at the inlet, outlet, and in Tributary A downstream for the following parameters:

- CBOD (5)
- Total Suspended Solids
- Total Phosphorus
- Dissolved Phosphorus
- Metals (total and dissolved, lead, zinc and copper)
- Escherichia coli
- Nitrate as N
- Chloride

The Consolidated Monitoring Program included the following water quality sampling requirements:

- One sample per season within one hour following the commencement of a storm event;
- One sample being for the snowmelt freshets;
- Five samples during summer months (June-September); and
- If flows permit, an additional sample should be taken 72 hours after precipitation.

Certain SWM Pond sampling events could not be performed due to various limitations imposed by the environmental conditions such as the lack of a spring freshet and the lack of precipitation from early April through October. Also, certain measurements in SWM Ponds 1 and 2 did not represent the intended conditions due to their lack of discharge during much of the year. Surface water quality results are given in the surface water monitoring report prepared by AECOM (Appendix III), and are summarized and discussed below.

The SWM Pond sampling showed a variety of exceedances of the provincial water quality objectives (PWQO), with a general pattern of higher concentrations within the ponds than in the receiving stream (Tributary A). These results are summarized in the surface water monitoring report (Appendix III), with tabulation of the results in the surface water report body and appendices.

The majority of the stream sites were within the ranges for PWQO. In the event that water quality samples were collected and the pH probe was not functioning, then the pH was determined by the lab.During some of the water base flow monitoring events, dissolved oxygen (DO) was below PWQO guidelines. This occurred once during the monitoring season at each of HC-A (03), HC-A (12) and HC-A (13). August 16th accounted for two of the three events. Lower DO levels observed on this date could be attributed to below average flow rates due to high temperatures and an extended period of no precipitation. A number of days where pH levels were above or below PWQO guidelines were also recorded. This occurred three times at HC-A (03) (2 events more acidic than PWQO guidelines, 1 more basic PWQO guidelines). Lower pH levels were observed once at each of HC-A (04), HC-A (11) and HC-A (14).

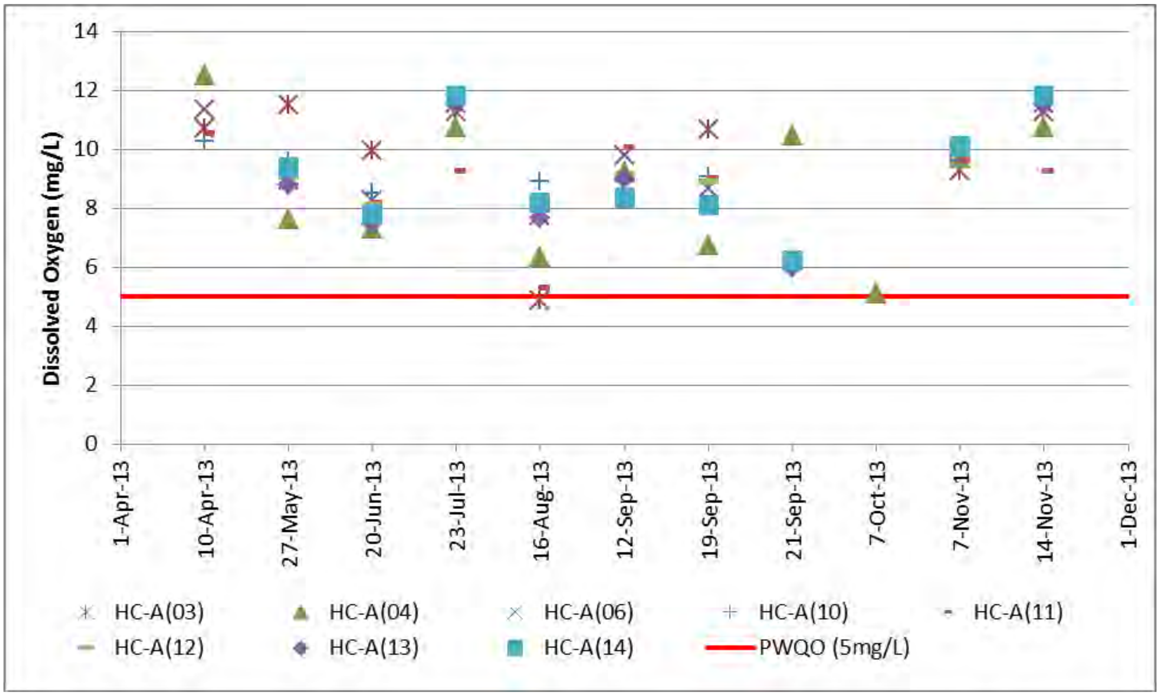


Figure 11. YSI Dissolved Oxygen Readings from 8 Monitoring Stations on Tributary A

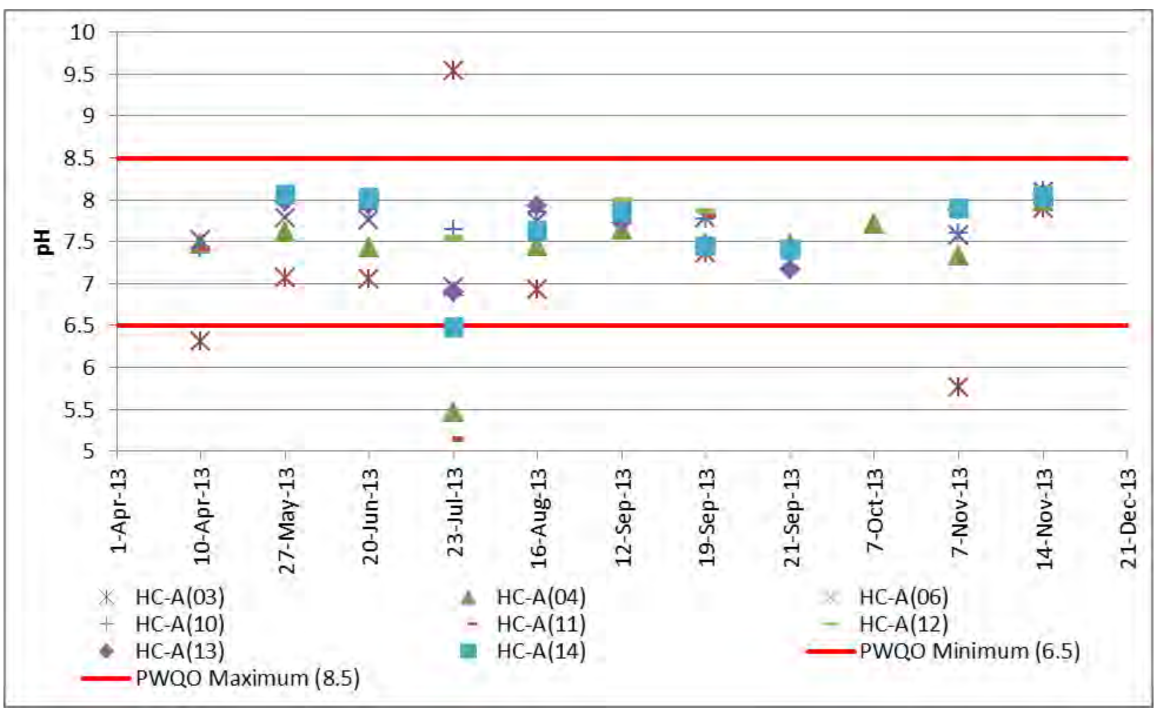


Figure 12.YSI pH Readings from 8 Monitoring Stations on Tributary A

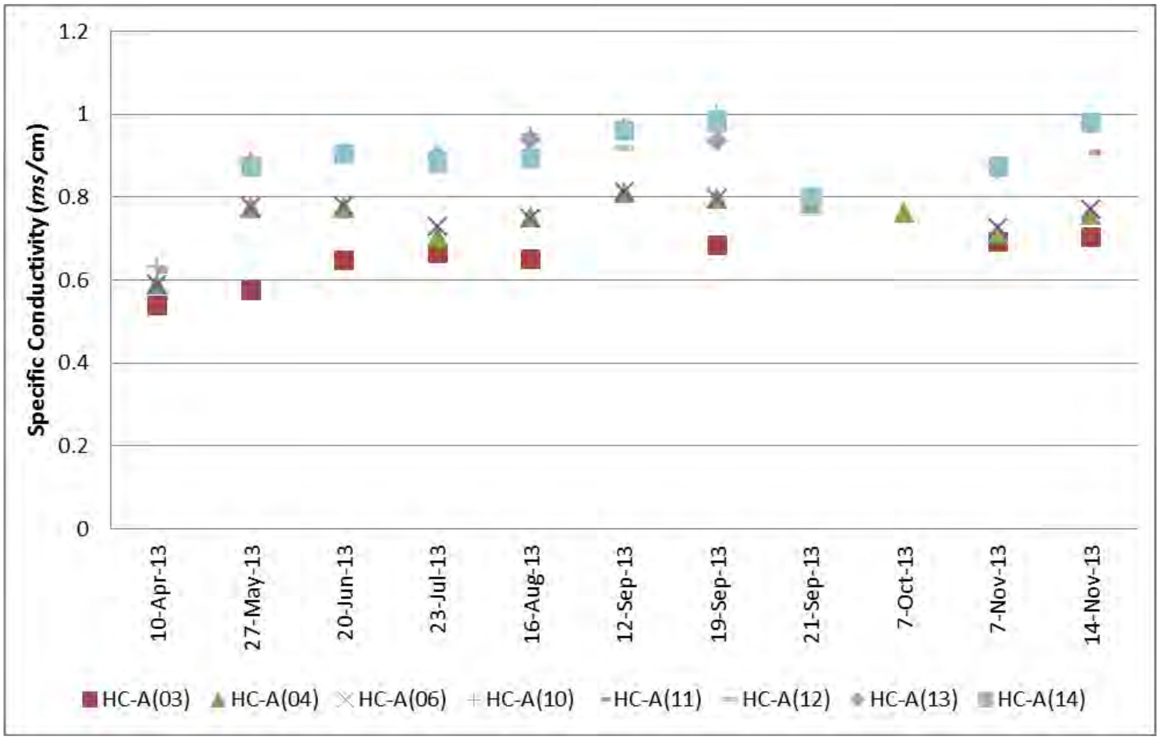


Figure 13.YSI Specific Conductivity Readings from 8Monitoring Stations on Tributary A

In 2013, four turbidity monitoring stations were installed along Hanlon Creek at stations HC-A(03), HC-A(06), HC-A(11) and HC-A(14). A Turner Designs Cyclops turbidity sensor uses an optical scattered light method to determine turbidity. Data was collected over the 2013 year; however some issues were encountered with the turbidity data. An error with the sensor at HC-A(06) caused the logger to record close to zero turbidity from September 14 to the end of the monitoring season. It appears that loggers at HC-A(11) and HC-A(14) were buried under sediment for extended periods of time causing the sensor to record maximum turbidity levels. It is recommended that the depths be adjusted in 2014 to avoid sediment overcoming the sensors. There is also potential that biofouling and vegetation growth in the stream interfered with the sensor readings during 2013.Turbidity readings at the four monitoring stations for 2013 are provided in Figure 14.

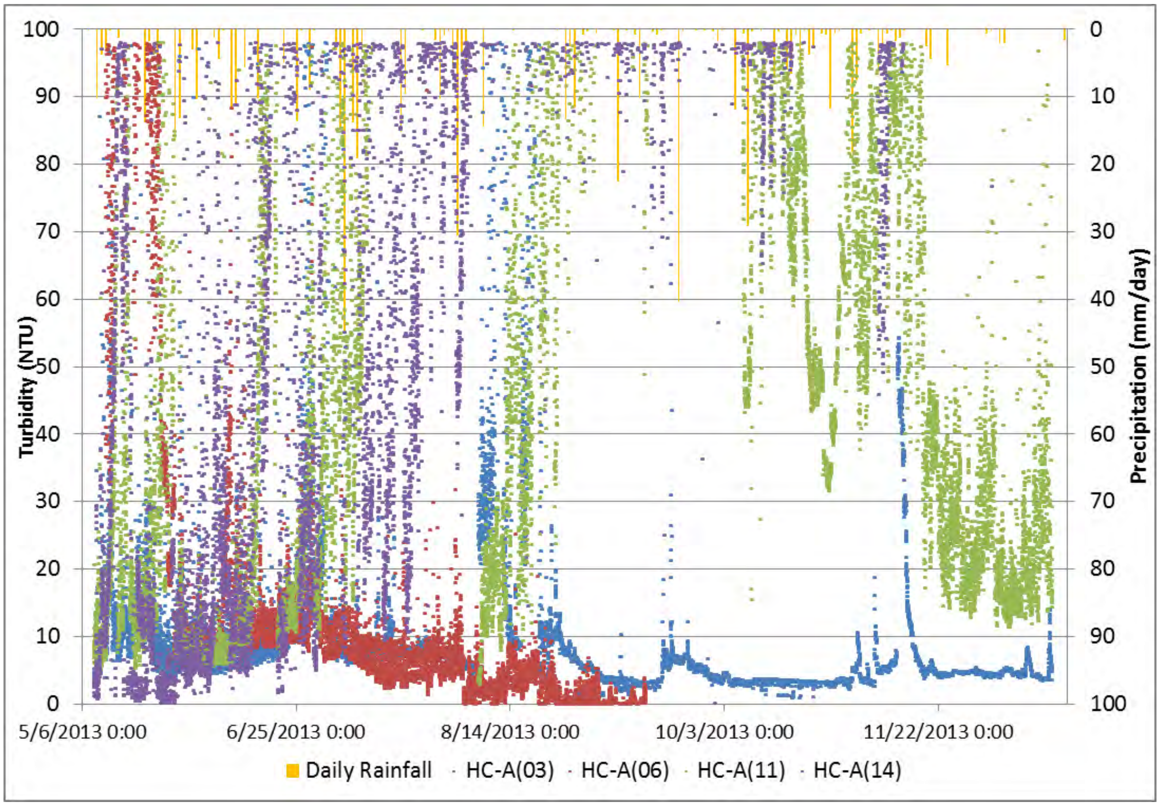


Figure 14.In-stream Turbidity Measurements for 2013

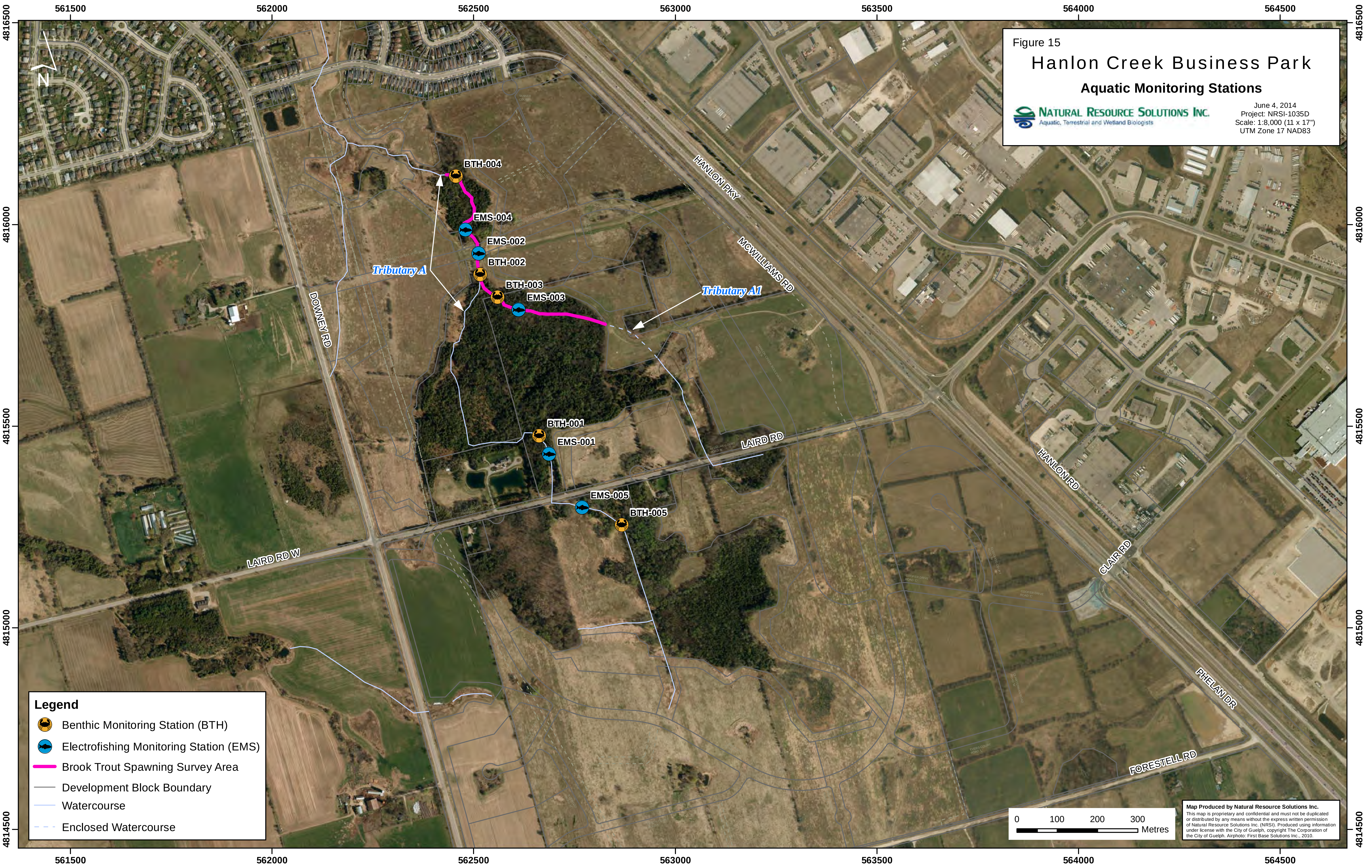
2.5 Aquatic Habitat and Biota

Aquatic monitoring was conducted for the benthic invertebrate community and the fish community within Tributary A and Tributary A1 of Hanlon Creek. Monitoring in 2013 was conducted at five different sites, each with a benthic invertebrate sampling station and a quantitative fish sampling station. At each station, aquatic habitat information was collected as well.In addition, brook trout spawning surveys were conducted on three separate occasions in the fall of 2013 along sections of Tributary A and Tributary A1. Locations of the ten sampling stations are shown on Figure 15 along with the brook trout spawning search area.

To assess the benthic community several indices were calculated to provide a characterization of the community at the station and to allow for comparisons across years. The indices calculated for 2013 were the Percent Model Affinity (PMA) index, which generates Percent Similar Community (PSC) values. Values that are higher than the critical PSC value indicate no impact, while values that are lower than the critical

PSC value indicate impact at that station. The additional indices that were calculated include taxonomic richness, EPT richness, and % dominant taxon.Detailed results are given in the 2013 aquatic monitoring report prepared by Natural Resource Solutions Inc. (Appendix IV) and are summarized and discussed in Section 2.5.1 below.

To assess the fish community multi-pass electrofishing surveys were conducted, which involved isolating a section of river using nets and electrofishing that section multiple times until a decline is noticed in the catches for each subsequent pass. Following the identification and enumeration of the catches, population estimates were calculated for each of the five monitoring stations using a least squares regression statistical method.Detailed results are given in the 2013 aquatic monitoring report prepared by Natural Resource Solutions Inc. (Appendix IV) and are summarized and discussed in Section2.5.2 below.



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2.5.1 Benthic Community

Results from the benthic invertebrate indices are shown on Figures 16, 17 and 18, and in Table 6. The results are discussed below.

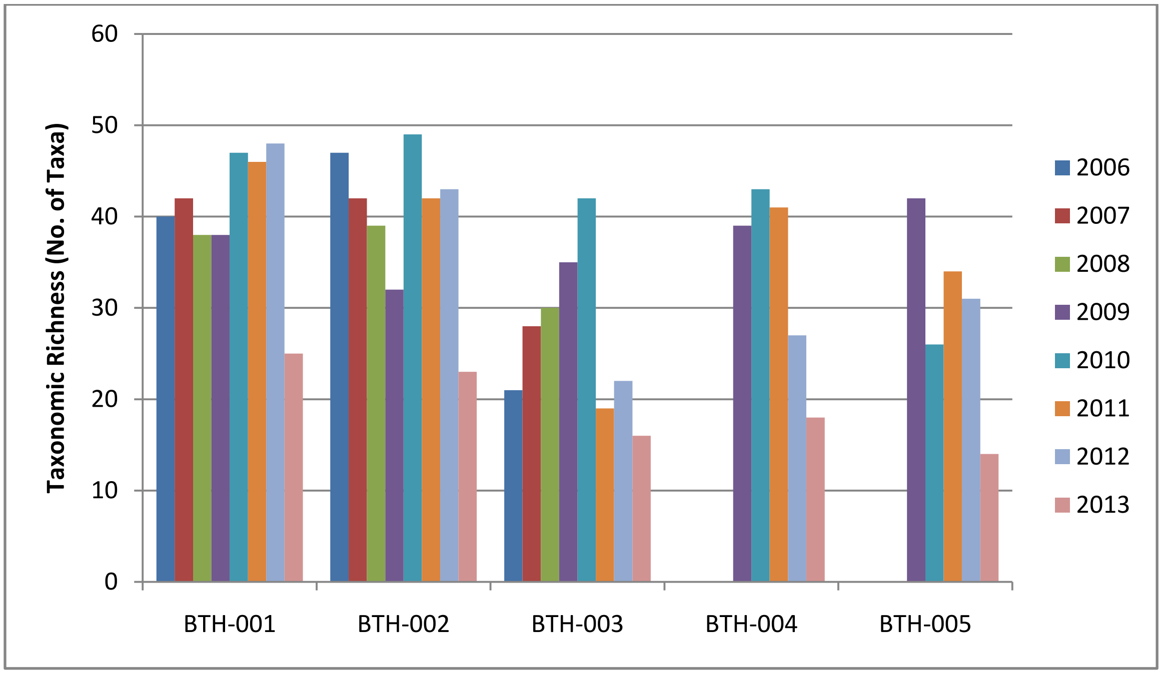

Figure 16.Benthic Invertebrate Taxonomic Richness for the Years 2006 to 2013

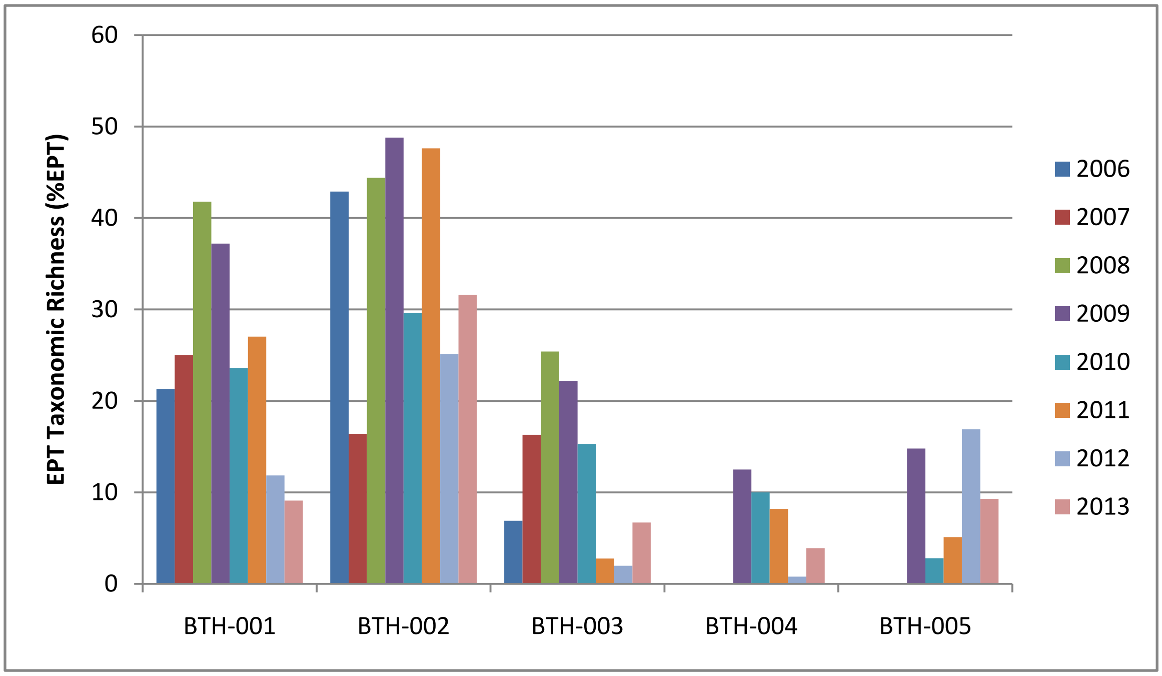

Figure 17.Benthic Invertebrate EPT Taxa Richness for the Years 2006 to 2013

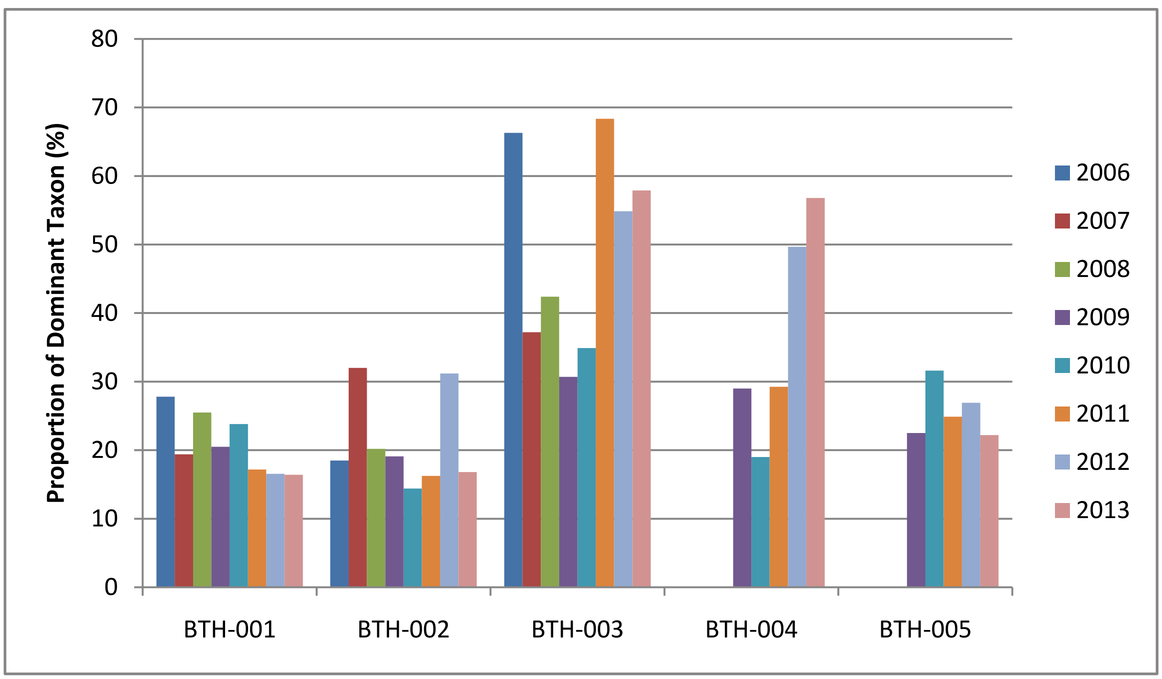

Figure 18.Benthic Invertebrate Proportion of Dominant Taxa for the Years 2006 to 2013

Table 6.Percent Similar Community Values and Impact Determination

Station	2006 Result	2007 Result	2008 Result	2009 Result	2010 Result	2011 Result	2012 Result	2013 Critical PSC	2013 Sample PSC	2013 Result
BTH – 001	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact	42.12	63.14	No Impact
BTH – 002	Impact	No Impact	Impact	Impact	No Impact	Impact	Impact	50.7	36.34	Impact
BTH – 003	No Impact	No Impact	No Impact	No Impact	No Impact	No Impact	Impact	42.12	28.72	Impact
BTH – 004	-	-	-	No Impact	No Impact	No Impact	Impact	42.12	28.39	Impact
BTH – 005	-	-	-	No Impact	No Impact	No Impact	No Impact	42.12	56.40	No Impact

<u>Station BTH-001</u>

Taxonomic richness has remained similar at station BTH-001 throughout the 5 years of pre-construction monitoring and into the early stages of construction-phase monitoring. The number of taxa has varied from 25 to 48 with the highest level of richness recorded in 2012 (Figure 16). Results for 2013 indicate a decline in the taxonomic richness at this station to the lowest that has been observed to date. However, this result is largely a function of the level of identification of the benthic invertebrates, which changed from 2012 to 2013. This change is discussed in detail in Section 5.3. No consistent trends have been established at BTH-001 as it relates to taxonomic richness.

The EPT richness values declined slightly at BTH-001 from 11.9 in 2012 to 9.1 in 2013. This value observed in 2013 signifies the lowest to date at this site as well as a continued decline that began with a substantial decrease between 2011 and 2012. EPT richness values were slightly higher in 2006, 2007, 2010, and 2011, with minor variations between years (Figure 17). The results from 2008 and 2009 stand out as being uncharacteristically high for this station. The decline in EPT richness that has been observed between 2011 and 2013resulted in a threshold exceedance for the second consecutive year at BTH-001. This threshold exceedance is discussed in Section 5.3.

The dominant taxon in 2013 belonged to *Orthocladiinae sp.*, a subfamily of Chironomidae. This includes species of non-biting midge (Diptera). Species belonging to this family are widely distributed, particularly throughout the North, inhabiting primarily freshwater lotic environments throughout erosional and depositional areas. These species are generally burrowers and belong to the functional feeding group 'collectors', including both gatherers and scrapers (Merritt *et al*. 2008). The conditions at station BTH-001 are consistent with this generalized habitat description providing silt, sand and gravel substrates, as well as moderately abundant detritus and woody debris. *Orthocladiinae spp.* exhibit a range of tolerances as it relates to water quality. However, in general they are indicative of good water quality (Mandaville 2002).This species represented 16.4% of the total number of individuals in the sample (Figure 18) and dominated the sample for the first time in 2013. The second and third most abundant species within the sample were also subfamilies belonging to the Chironomidae family. These were *Tanypodinae* and *Chironominae*, which comprised 14.6% and 13.8% of the sample, respectively. The remainder of the sample was largely comprised of three different species, including *Caecidoteaintermedius* (11.1%), *Optioservus sp.* (10.8%), and *Gammaruspseudolimnaeus*(10.7%), most of which have provided a large representation within the samples through the previous years of monitoring. This site has exhibited a shift in dominant taxa since benthic sampling began in 2006. Dominant taxa previously found at this site included *Micropsectra*spp., a true fly (Dipteran) of the family Chironomidae in 2006 and 2007, *Diplectronamodesta*, a caddisfly (Trichopteran) of the family Hydropsychidae in 2008 and 2009, *Caecidotea intermedius*, a sowbug (Isopoda) of the family Asellidaein 2010 and 2011, and Optioservus sp., a riffle beetle (Coleoptera) belonging to the Elmidae in 2012.

The PMA index continued to show “no impact” in 2013. This has been a consistent result throughout all years of pre-construction monitoring, beginning in 2006, and continuing during construction-phase monitoring (Table 6). Prior to 2013 the overall results suggest that habitat and water quality conditions at station BTH-001 have generally remained consistent, aside from some expected natural variation. The decrease in EPT species at this site in 2013 indicates a potential change in conditions, however based on the PMA assessment this change was not enough to characterize the site as being ‘impacted’. These patterns will be further assessed during construction-phase monitoring in 2014.

<u>Station BTH-002</u>

Taxonomic richness at station BTH-002 was 23 in 2013. Results show a steep decline in the taxonomic richness between 2012 (taxonomic richness = 42) and 2013 to the lowest level that has been observed to date. Previously, the lowest observed richness at

BTH-002 was 32 in 2009, which increased to a high of 49 in 2010 (Figure 16). The result in 2013 is likely a function of the level of identification of the benthic invertebrates, which changed from 2012 to 2013. This change is discussed in detail in Section 5.3. No consistent trends have been established at BTH-001 as it relates to taxonomic richness. The decrease in taxonomic richness did not exhibit a greater than 50% decline in 2013, and therefore did not exceed the threshold.

The EPT richness was 31.6% in 2013, a slight increase from 25.1%, which was observed in 2012. This metric has shown no obvious increasing or declining trend since 2006. EPT richness has frequently been high (above 40%) with large declines noted in 2007 (16.4%), 2010 (29.6%), and most recently in 2012 (Figure 17). Further to this, it has never experienced declining richness values over consecutive years.

The dominant taxa included two species at station BTH-002 in 2013. The first was *Gammaruspseudolimnaeus*, a species of Amphipoda belonging to the family Gammaridae. Species belonging to this family occur primarily in shallow waters, resting among vegetation and debris, or slightly within soft substrate. These habitat characteristics are not entirely consistent with the substrates typically found at this site, which are dominated by cobble and gravel. However, some finer sediment was observed in addition to the presence of small amounts of woody debris and detritus, which could provide appropriate habitat for *G.pseudolimnaeus*. *G. pseudolimnaeus* are indicative of very good water quality (Mandaville 2002).The second species was *Diplectronamodesta*, a species of caddisfly (Trichoptera) belonging to the family Hydropsychidae. Species belonging to the genus *Diplectrona* inhabit the erosional areas of headwater streams as clingers (net spinners or fixed retreats) and are collectors that filter course particles, particularly detritus (Merritt *et al.* 2008).*D. modesta* are indicative of good water quality (Mandaville 2002).Both of these taxa represented 16.8% of the total number of individuals in the sample. The result for % dominant taxon has generally been lower at this station over the years of monitoring, with 2007 and 2012being relatively high(32.0% and 31.2%, respectively) (Figure 18). The dominant taxonomic group has changed several times during pre-construction monitoring. In 2006, the dominant group was the genus *Sialis*of the order Megaloptera and family Sialidae. In 2007 and 2008, the dominant group was the genus *Micropsectra*of the order Diptera and family Chironomidae and in 2009 the dominant group was the genus

Cheumatopsyche spp., a species of caddisfly (Trichoptera) belonging to the family Hydropsychidae. In 2010 and 2011, the dominant group was *Leuctra spp.* of the order Plecoptera, a species that inhabits swift, rocky-bottomed streams, and occasionally intermittent streams (McCafferty 1981). *G.pseudolimnaeus* represented the dominant taxa in 2012 as well but comprised a larger proportion of the sample compared to 2013.

The PMA index in 2013 showed "impact" for the third consecutive year. Results since pre-construction monitoring began in 2006 have been inconsistent, showing no reliable trend of "impact" or "no impact". 'Impact' has been the most common result, with 'no impact' observed following only 2 years of analysis in 2007 and 2010 (Table 6). The predominance of the "impact" result should not be construed to mean that station BTH-002 is in poorer condition than the other stations. This station is the only station that uses the cobble/gravel model community for PMA index, and it was chosen based on the habitat characteristics of the station. Because of this difference, comparisons among the other 4 stations using the PMA index are not valid. The monitoring program is intended to provide temporal comparison within stations.

Station BTH-003

Taxonomic richness at station BTH-003 was 16 in 2013, a slight decrease from 2011 and 2012, which followed a substantial decreasethat was experienced between 2010 and 2011 (Figure 16). The results in 2013 are the lowest that has been recorded at this site since sampling began. This result is likely a function of the level of identification of the benthic invertebrates, which changed from 2012 to 2013. This change is discussed in detail in Section 5.3.Over the 5 years of monitoring prior to 2011 species richness had increased steadily by 50%, beginning in 2006 with a measure of 21 and increasing to 42 in 2010. The results observed between 2011 and 2013 appear to be a return to the degree of taxonomic richness that was observed in 2006.

The EPT richness was 6.7% in 2013, an increase from 2.0% in 2012, which was the lowest proportion of EPT taxa that had been observed at the site. Results have varied through the years with an increasing trend observed during the first three years of monitoring and a decreasing trend during the four years prior to 2013 (Figure 17). The EPT richness value seen in 2013 at this station is similar to what was calculated in the first year of monitoring, when EPT taxa richness was 6.9%. Results for 2013 also represent a positive response after the threshold exceedance that occurred in 2012.

The dominant taxon in 2013 was *Gammaruspseudolimnaeus*, similar to Station BTH-002, which comprised 57.8% of the total sample (Figure 18). This marks the second consecutive year that *G. pseudolimnaeus* has been the dominant species. Prior to 2012, the dominant taxon was *Micropsectra*spp., a Dipteran species that had previously been the dominant taxon throughout all six years of pre-construction monitoring. Although the dominant taxa changed in 2012, the proportion of *Micropsectra spp.*within the sample was similarly high following 2011, comprising 30.2% of the sample. In 2013 the proportion of *Micropsectra spp.* within the sample continued to decline and was replaced by *Orthocladiinae spp.* as the second dominant species representing 11.6%. In addition, the proportions of other species began to increase. This saw increases in *Tanypodinae spp.* and *Chironominae spp.* (Chironomid) *Caecidotea intermedius* (Isopod), and *Leuctra sp.* (Plecoptera). Although there was an increase in the proportions of other species within the sample, there was a decrease in the taxonomic richness. This is a product of not only the dominance of *G. pseudolimnaeus*but also the high density of the species relative to the others within the sample. Both *Micropsectrasp.* and *G.pseudolimnaeus* prefer soft substrates and the shallow areas of both lotic and lentic environments. The preference of this species for depositional areas explains their abundance at station BTH-003, because this station occurs in a slow-flowing area with abundant detritus and underlying substrates dominated by silt and clay.*G. pseudolimnaeus* are indicative of very good water quality (Mandaville 2002).

The PMA analysis showed “impact” in 2013, which is the second consecutive year that this result has been found (Table 6). Prior to 2011 the results suggested that habitat and/or water quality conditions at station BTH-003 were generally improving as evidenced by a consistent increase in species diversity (taxonomic richness). Results in 2011 and 2012, however, suggested a change in the habitat conditions at this site leading to results that are similar to those observed in 2006. This was demonstrated through a decrease in taxonomic richness and EPT taxa richness, and a large increase in the proportion of the dominant taxon, *Micropsectra*spp in 2011, and *G.pseudolimnaeus* in 2012. However, since this change was consistent with pre-construction monitoring results in 2006, it was attributed to natural variation. Results in

2013 have remained similar to those in 2012 with the exception of a slight increase in EPT taxa. These levels are more similar to results from 2006, with the exception of the PMA ‘impact’ determination. In 2012, the PMA ‘impact’ determination was attributed to lower baseflows and variation in the natural conditions of the site, however conditions were markedly different in 2013 with higher than average baseflows. In 2013 the two consecutive years of an ‘impact’ determination following two years of ‘no impact’ resulted in the exceedance of the first threshold. However, due to the differences in habitat conditions between 2012 and 2013, particularly in the amount of flow, it is difficult to determine the cause of the exceedance. Sampling in 2014 may provide a better understanding of the benthic community at BTH-003 and its responses to the changing habitat conditions.

Station BTH-004

This was the fifth consecutive year of sampling conducted at this station, which began in 2009. Taxonomic richness at Station BTH-004 was 18 in 2013, which marks a continued decline in taxa richness that began in 2010 with 43(Figure 16). However, in 2013 this decline was likely a function of the level of identification of the benthic invertebrates, which changed from 2012 to 2013. This change is discussed in detail in Section 5.3.

The EPT richness was 3.9% in 2013, an increase from 0.8% in 2012 (Figure 17), which was the lowest proportion of EPT taxa that has been observed at station BTH-004 and the lowest observed EPT richness value that has been seen at any of the five stations to date. Results from 2013 show a slight recovery in EPT richness values compared to those in 2012, which resulted in an exceedance of the third threshold in 2012. The EPT richness values at BTH-004 have been relatively low in relationto the other four monitoring stations with the highest proportion of EPT taxa occurring in 2009 (12.5%).

The dominant taxon at BTH-004 in 2013 was *Gammaruspseudolimnaeus*, similar to Stations BTH-002 and BTH-003. As noted above, this species generally inhabits the shallow, depositional areas of both lotic and lentic environments within soft substrates and detritus. This is consistent with the habitat characteristics of BTH-004, which is comprised exclusively of fine substrates including silt and sand. Woody debris and detritus are also present throughout the site. This species represented 56.8% of the total sample in 2013 (Figure 18) and was the dominant taxa at this site for the second consecutive year, increasing in proportion from 49.7% in 2012. Prior to 2012, the dominant taxa was identified as *Caecidotea intermedius*, a species of aquatic sowbug, which dominated the sample in 2010 and 2011. Both *C. intermedius* and *G. pseudolimnaeus* inhabit shallow waters where detritus is present and are likely to coexist in the majority of habitats. *G. pseudolimnaeus* has consistently occurred at this station and represented the second most dominant taxa at 16.4% in 2011.

Similar to BTH-003 the PMA analysis showed “impact” at station BTH-004 in 2013 (Table 6). This signifies the second consecutive year of an ‘impact’ determination following two years of ‘no impact’ resulted in an exceedance of the first threshold. However, due to the differences in habitat conditions between 2012 and 2013, particularly in the amount of flow, it is difficult to determine the cause of the exceedance. Further monitoring in 2014 may facilitate a better understanding of changes to the benthic community at BTH-004.

Station BTH-005

This was the fifth consecutive year of sampling conducted at this station, which began in 2009. Taxonomic richness at Station BTH-005 was 14 in 2013, which marks the lowest result observed at this station since monitoring began in 2009. This result is likely a function of the level of identification of the benthic invertebrates, which changed slightly from 2012 to 2013. This change is discussed in detail in Section 5.3. To date, the highest taxonomic richness value was observed in 2009 with a value of 42 (Figure 16). Between 2012 and 2013 the taxonomic richness decreased substantially from 31 to 14, which signifies a greater than 50% decrease in the taxa richness and an exceedance of the second threshold at BTH-005. However, as stated above this exceedance may be explained by the change in the level of identification. Prior to 2013, the taxonomic richness values appear relatively stable with no obvious increasing or decreasing trends. No apparent changes in habitat conditions were identified during sampling that would indicate that the decline in taxonomic richness is related to habitat conditions.

The EPT taxonomic richness was 9.3% in 2013, a decrease from 16.9% in 2012 (Figure 17). Results from 2012 represent the highest proportion of EPT taxa that have been seen at this station and are similar to monitoring results from 2009. EPT taxa richness values from 2010 and 2011 stand out as unusually low when compared to other years of monitoring at this station with results of 2.8 and 5.1, respectively.

The dominant taxon at BTH-005 was *Orthocladiinae* in 2013, similar to Station BTH-001. Station BTH-001 is located 170m downstream from BTH-005 on the opposite (north) side of Laird Road. This sub-family of Chironomidae is in the order Diptera (true flies), and includes a variety of species of non-biting midges representing 22.2% of the overall sample. As described above, they inhabit the depositional and erosional areas of lotic environments. Prior to 2013 the dominant taxa was *Caecidotea* sp., which includes a variety of sowbugspecies. The occurrence of species belonging to the family Asellidae in a diversity of habitats and their association with groundwater may explain their presence at this station. As seen at the majority of sampling stations, dominant taxa have generally comprised approximately 20% to 30% of the overall sample. The species *Gammaruspseudolimnaeus*was the second most abundant species at BTH-005, representing 21.6% of the total sample in 2013 similar to 2012 when it comprised 10.0% of the sample. This species also represented a large proportion of the sample upstream at BTH-001 in 2013.

The PMA analysis continued to show “no impact” in 2013, consistent with the results from 2009 and 2012 (see Table 6). Some minor fluctuations have been observed relating to taxonomic richness, EPT richness and the proportion of dominant taxa at BTH-005. This is to be expected and is attributable to natural variations in habitat conditions. In general the benthic community at BTH-005 appears healthy and stable.

2.5.2 Fish Community

During 2013 construction-phase aquatic monitoring a total of 735 individual fish were captured representing seven different species: blacknose dace (*Rhinichthysobtusus*), brook stickleback (*Culaeainconstans*), central mudminnow (*Umbra limi*), creek chub (*Semotilusatromaculatus*), fathead minnow (*Pimephalespromelas*), northern redbelly dace (*Chrosomuseos*), and white sucker (*Catostomuscommersonii*). The total catch recorded in 2013 is the highest that has been recorded since sampling began in 2006 and is substantially higher than the second highest catch, which was recorded the previous year in 2012 to be 260. This however includes catches from five stations, which cannot be accurately compared to the years 2006, 2007 and 2008 when only three stations were sampled. With that in mind the third highest catch was recorded in 2007 when 247 fish were captured. The total number of fish captured prior to 2013 ranged from 92 to 260.Results and population estimates for each station are shown on Figure 19 and are discussed below.

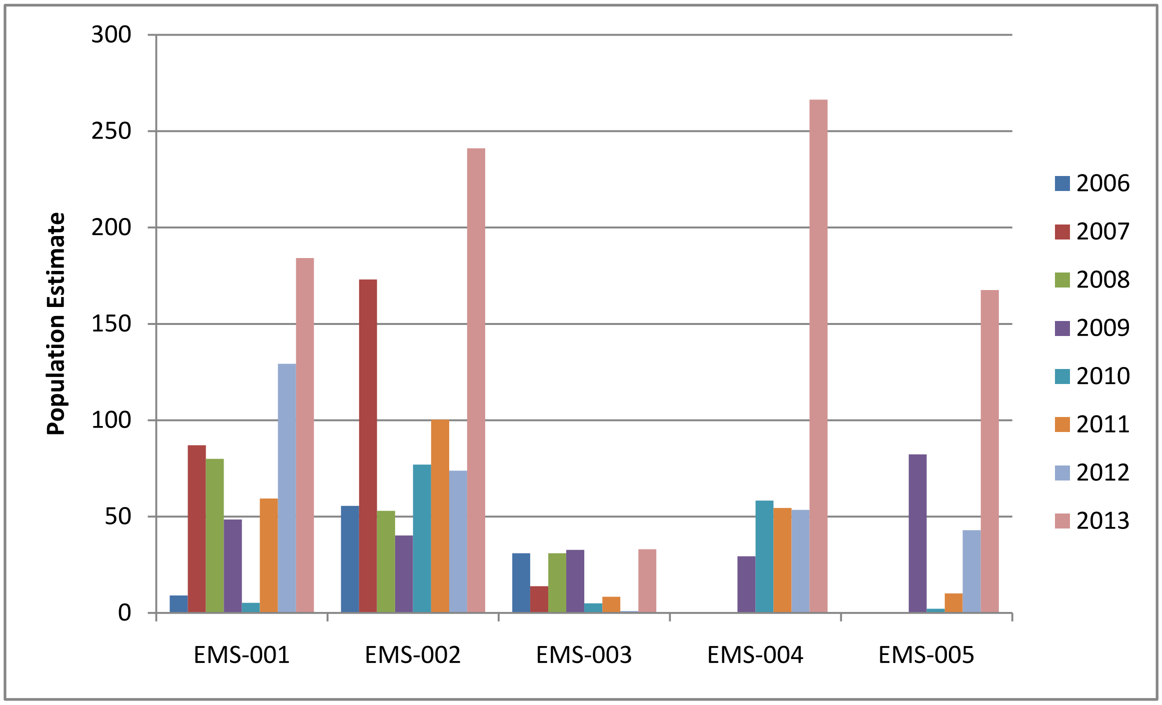

Figure 19.Population Estimates at Electrofishing Stations for the Years 2006 to 2013

<u>Station EMS-001</u>

Electrofishing in 2013 resulted in the capture of five fish species. They were blacknose dace, brook stickleback, central mudminnow, creek chub, and white sucker. A combined total of 178 individual fish were captured through a total of three passes. This marks the first year that white sucker has been recorded at this station since aquatic monitoring began in 2006. All other species have been captured here throughout previous years of monitoring with blacknose dace being captured during every year. Additionally, northern redbelly dace, a coolwater species that was captured for the first time at this site and during this monitoring program, was not captured in 2013. The detailed results are provided in Table 13of the aquatic monitoring report (Appendix IV).

The estimated number of fish at station EMS-001 has increased substantially since 2010. This increase follows a three year decline that began in 2008 with an estimated population of approximately 87 and ended in 2010 with an estimated population of approximately five.In 2011 the estimated population increased to 59 and then increased again to 129 in 2012. Sampling in 2013 marks the third consecutive year that the population has increased. The estimated fish population in 2013 at EMS-001 is the highest that has been observed at this station since sampling began in 2006, with a previous high of approximately 129 in 2012. These numbers are much higher than the estimated pre-construction populations.

Station EMS-002

Electrofishing in 2013 resulted in the capture of five fish species and a combined total of 193 individual fish in a total of three passes. The species captured were blacknose dace, brook stickleback, central mudminnow, creek chub, and white sucker. Blacknose dace and brook stickleback have been captured at this station every year while central mudminnow and creek chub have been captured sporadically over the previous years. White sucker was captured for the second consecutive year at this station. Prior to 2012 this species had not been captured at any of the five monitoring stations. Additionally, mottled sculpin (*Cottusbairdii*), a coldwater species that was captured for the first time at this site in 2011 was not captured in 2012 or 2013.The detailed results are provided in Table 14 of the aquatic monitoring report(Appendix IV).

The estimated fish population at EMS-002 has exhibited no obvious trend since sampling began in 2006. The estimated numbers have experienced a great deal of variation with the lowest estimate occurring in 2009 (approximately 40). The estimated population in 2013 was approximately 241, which stands out as an exceptionally high year in comparison to previous years of monitoring and is the highest estimate observed at this site to date.

Station EMS-003

Electrofishing in 2013 resulted in the capture of two fish species and a combined total of 28 individual fish over three passes. The species captured were blacknose dace and brook stickleback. Electrofishing results at this station indicate a low diversity of species relative to the other stations as only two species have been consistently captured here since 2007 (blacknose dace and brook stickleback). Three species were captured in 2006, which also included creek chub. The detailed results are provided in Table 15 of the aquatic monitoring report(Appendix IV).

Population estimates at EMS-003 have been consistently low relative to the other stations within the HCBP study area. The estimate calculated in 2013, while the highest ever observed at this site was still very similar to estimates in pre-construction years, including 2006, 2008, and 2009. The population also exhibited a relatively substantial increase from the previous three years of monitoring, which saw the population estimates decrease to a historical low of one in 2012.

<u>Station EMS-004</u>

Electrofishing took place at this site for the first time in 2009 and has been sampled every year since, including 2013. Electrofishing in 2013 resulted in the capture of five fish species and a combined total of 197 individual fish over three passes. The species captured included backnose dace, brook stickleback, central mudminnow, creek chub, and white sucker. Prior to 2013, a total of four species had been captured at this station with blacknose dace and brook stickleback being captured consistently. Creek chub was also captured in 2010 and 2012 and central mudminnow was captured in 2011 and 2011. Similar to EMS-001, white sucker was captured at this station for the first time in 2013. The detailed results are provided in Table 16of the aquatic monitoring report (Appendix IV).

The largest overall increase in population estimates in 2013 was seen at station EMS-004. Estimates have remained relatively consistent between 2009 and 2012 ranging from approximately 29 to 58. In 2013 the population estimate was approximately 266. This is a significant increase in the population at this station and is also the highest estimate that was observed at any of the five monitoring stations in 2013 and to date.

<u>Station EMS-005</u>

Electrofishing took place at this site for the first time in 2009 and has been sampled every year since, including 2013. Electrofishing in 2013 resulted in the capture of seven fish species and a combined total of 139 individual fish over four passes. The species captured included blacknose dace, brook stickleback, central mudminnow, creek chub, fathead minnow, northern redbelly dace, and white sucker. This station has typically contained between two and three species since 2006. Blacknose dace has been captured during every year of sampling at this station. Brook stickleback, central mudminnow and creek chub have also been captured throughout previous years of monitoring. In 2013, three new species were captured at stations EMS-005 including fathead minnow, northern redbelly dace, and white sucker. These species have previously been captured during the monitoring program. The detailed results are provided in Table 17of the aquatic monitoring report (Appendix IV).

The population estimate at station EMS-005 in 2013 was approximately 167.5. This is the highest population estimate that has been observed at this site since sampling began in 2009.This also marks the third year that the population has increased at this station since it reached a low of two in 2010.

2.6 Terrestrial Habitat and Biota

Eight vegetation plots were monitored in 2006, with an additional plot added in 2007 and two more added in 2011. Since 2007, 9 permanent vegetation plots have been sampled each year, with 11 permanent plots sampled in 2011, 2012, and 2013. The vegetation monitoring stations are shown on Figure 16. Each randomly selected permanent plot is 10x10m in size. Trees and shrubs were surveyed in each plot. Within each plot, 5 subplots were used again in 2013 for sampling herbaceous plant species. Following 2012 surveys, soil surveys were discontinued as part of the regular monitoring program, as the data collected does not change in the short-term and ongoing hydrological studies are best-suited to inform any changes in groundwater conditions. Original soil surveys were used to classify the vegetation community through ELC, but subsequent surveys have had minimal value in assessing changes within each monitoring plot. Soil data that was collected prior to the 2013 monitoring program can be seen in previous terrestrial and wetland monitoring reports.

Breeding bird point counts were performed according to the standard Ontario Breeding Bird Atlas protocol (OBBA 2001). Ten-minute point counts were conducted at a total of 13 stations in 2013. Bird species, breeding evidence, and the number of birds encountered were recorded. The breeding bird plots coincide with the nine vegetation plots in addition to one station that was added in 2009, and three more that were added in 2011.

Amphibian monitoring focused on calling anurans during 3 minute call counts. Call intensity and an estimated number of amphibian individuals were recorded following the Marsh Monitoring Program protocol (Bird Studies Canada 2008). In order to compare species abundance over time and between stations, the maximum call code is used. The maximum call code is used to provide an estimate of abundance, as estimating numbers of individuals is not accurate. The three call codes as per the Marsh Monitoring Protocol (BSC 2008) are:

Call Level 1. Calls can be counted; not simultaneous
Call Level 2. Some simultaneous calls; yet distinguishable
Call Level 3. Calls not distinguishable; overlapping (i.e. “full chorus”)

Evening amphibian call count surveys were conducted in 2013 at 16 stations (see Figure 20). The amphibian plots coincide with six of the nine vegetation plots in addition to one station that was added in 2007, eight stations that were added in 2009, and one station that was added in 2011.

Incidental observations of all wildlife (i.e. birds, mammals, butterflies, dragonflies, reptiles, etc.) were documented during all field visits conducted in 2013, including all construction inspection visits that were conducted in spring (March, April, May) and late summer (September, October) in Phases 1 and 2. This included actual observations of individuals, as well as signs of animal presence, such as tracks, scat, trails, dens, etc.

Detailed results for the terrestrial habitat and biota are given in the 2013 terrestrial and wetland monitoring report prepared by Natural Resource Solutions Inc. (Appendix IV) and are summarized and discussed in Sections 2.6.1, 2.6.2 and 2.6.3 below.

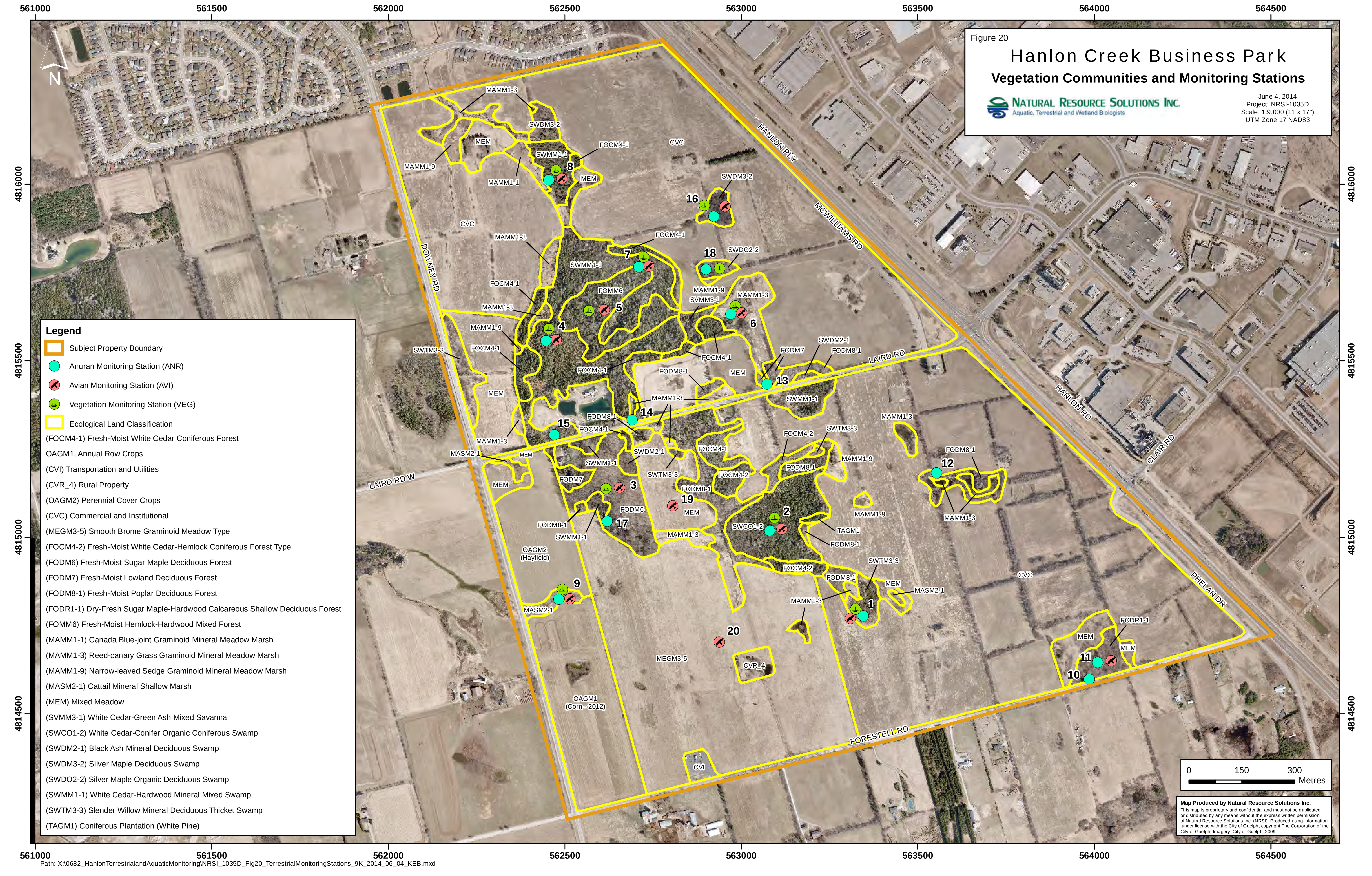
Figure 20
Hanlon Creek Business Park
Vegetation Communities and Monitoring Stations
June 4, 2014
Project: NRSI-1035D
Scale: 1:9,000 (11 x 17")
UTM Zone 17 NAD83
NATURAL RESOURCE SOLUTIONS INC.
Aquatic, Terrestrial and Wetland Biologists
Legend
Subject Property Boundary
Anuran Monitoring Station (ANR)
Avian Monitoring Station (AVI)
Vegetation Monitoring Station (VEG)
Ecological Land Classification
(FOCM4-1) Fresh-Moist White Cedar Coniferous Forest
OAGM1, Annual Row Crops
(CVI) Transportation and Utilities
(CVR_4) Rural Property
(OAGM2) Perennial Cover Crops
(CVC) Commercial and Institutional
(MEGM3-5) Smooth Brome Graminoid Meadow Type
(FOCM4-2) Fresh-Moist White Cedar-Hemlock Coniferous Forest Type
(FODM6) Fresh-Moist Sugar Maple Deciduous Forest
(FODM7) Fresh-Moist Lowland Deciduous Forest
(FODM8-1) Fresh-Moist Poplar Deciduous Forest
(FODR1-1) Dry-Fresh Sugar Maple-Hardwood Calcareous Shallow Deciduous Forest
(FOMM6) Fresh-Moist Hemlock-Hardwood Mixed Forest
(MAMM1-1) Canada Blue-joint Graminoid Mineral Meadow Marsh
(MAMM1-3) Reed-canary Grass Graminoid Mineral Meadow Marsh
(MAMM1-9) Narrow-leaved Sedge Graminoid Mineral Meadow Marsh
(MASM2-1) Cattail Mineral Shallow Marsh
(MEM) Mixed Meadow
(SVMM3-1) White Cedar-Green Ash Mixed Savanna
(SWCO1-2) White Cedar-Conifer Organic Coniferous Swamp
(SWDM2-1) Black Ash Mineral Deciduous Swamp
(SWDM3-2) Silver Maple Deciduous Swamp
(SWDO2-2) Silver Maple Organic Deciduous Swamp
(SWMM1-1) White Cedar-Hardwood Mineral Mixed Swamp
(SWTM3-3) Slender Willow Mineral Deciduous Thicket Swamp
(TAGM1) Coniferous Plantation (White Pine)
0 150 300 Metres
Map Produced by Natural Resource Solutions Inc.
This map is proprietary and confidential and must not be duplicated or distributed by any means without the express written permission of Natural Resource Solutions Inc. (NRSI). Produced using information under license with the City of Guelph, copyright The Corporation of the City of Guelph. Imagery: City of Guelph, 2009.
HANLON PKY
MCWILLIAMS RD
LAIRD RD
LAIRD RD W
DOWNEY RD
HANLON RD
CLAIR RD
PHELAN DR
FORESTELL RD
Path: X:\0682_HanlonTerrestrialandAquaticMonitoring\NRSI_1035D_Fig20_TerrestrialMonitoringStations_9K_2014_06_04_KEB.mxd

2.6.1 Vegetation and Soils

Refer to the 2013terrestrial and wetland monitoring report (Appendix IV) for a comprehensive list of the vegetation species observed from 2006 to 2013. A total of 96 vegetation species were recorded in 2006, 109 in 2007, 107 in 2008, 116 in 2009, 122 in 2010, 129 in 2011, 147 in 2012, and 146 in 2013. Overall, 273 different species have been observed in the vegetation monitoring plots. In 2013, the 146 species included14 species not previously recorded within the vegetation monitoring plots, 10 of which were native species. None of the species observed are federally or provincially rare; however, in 2013, NRSI observed one regionally significant species; clearweed (*Pileapumila*), which is considered rare within Wellington County. A total of 12 regionally significant species have been observed throughout HCBP monitoring plots between 2006 and 2013. Clearweed was previously observed in 2008.

2.6.1.1 Floristic Indices

A common method for evaluating and assessing natural areas is using floristic composition. This method is based on the character of a region's flora. There are several floristic indices which can be used to describe the character of the vegetation in the plot. These include the Coefficient of Wetness (CW), the Coefficient of Conservatism (CC), and the Natural Area Index (NAI). All species (herbs, shrubs, and trees) from each plot are considered in these equations.

<u>Coefficient of Wetness</u>

The CW is based on wetland values given to each individual plant species. Values range from -5 to +5, where -5 indicates an obligate wetland species, and +5 indicates an obligate upland species. "0" is assigned to facultative species, those that are just as likely to be found in wetland or upland habitats.Figure 21 shows the average wetness per plot, based on the wetness coefficients of all species found within a plot. Most plots are wetlands. Plots 3 and 5 are upland, designated as a sugar maple forest and cedar-coniferous forest respectively. Plot 1 remains the wettest plot, with an average CW score of -3.68 in 2013. This plot is located in a reed-canary grass marsh. Plot 9 (cattail marsh) continues to indicate a trend of decreasing CW values (becoming wetter), a trend that has developed since the 2010 monitoring season. This is likely attributed to Plot 5, which had shown a steady trend of becoming wetter (dropping to a negative CW value in

2012) and rebounded slightly to show an average CW value of 0.00. As mentioned in previous monitoring reports, this plot is dominated by white cedar (*Thujaoccidentalis*), a species known to tolerate a wide range of soil moisture conditions. Additionally, aside from the four tagged tree species which have been present within Plot 5 since the beginning of monitoring in 2006, in 2013 a single herbaceous species, field horsetail (*Equisetum arvense*) was recorded in the plot. Plots which contain a low diversity of species are more susceptible to data fluctuations as the addition or removal of a single species can significantly impact calculations. In the case of Plot 5, observations of upland species with high CW values in previous years have produced higher average CW values. It is important to note that upland species which have been observed in the plot in previous years were outliers to the overall dominant species composition, often less than 5 individuals of a herbaceousspecies struggling to establish. As the average CW does not account for abundance and only provides an analysis of the overall species list, outlier species can inflate average CW values for low diversity plots. Plot 3 (sugar maple forest) continues to exhibit the driest average CW value (1.86).Both Plot 16 and Plot 18 have shown a steady drying trend over the three years of monitoring in these plots.

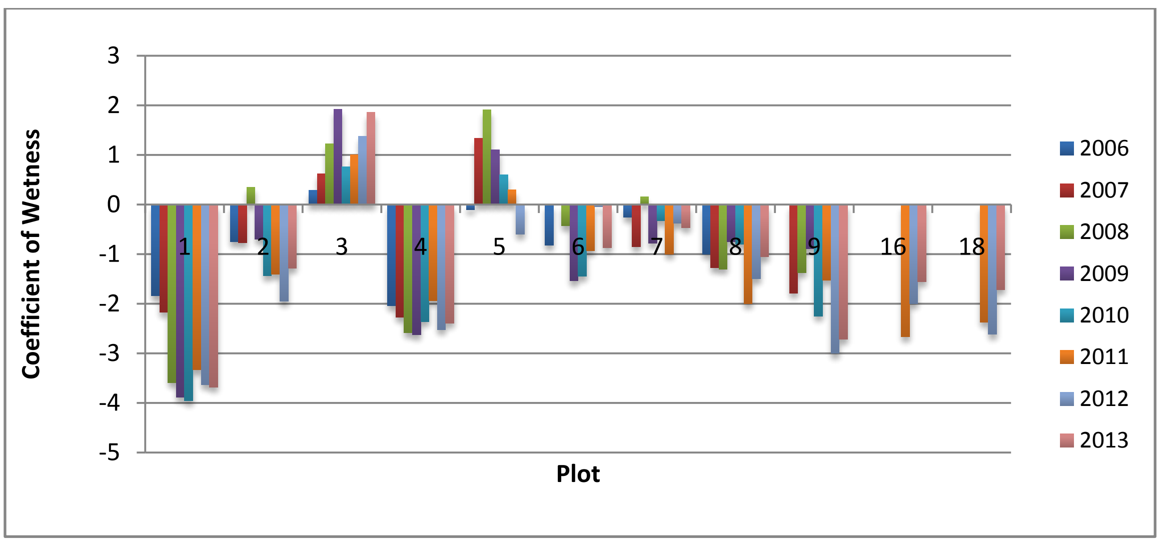

Figure 21.Coefficient of Wetness by Plot 2006 - 2013

Coefficient of Conservatism

For the CC, each species is given a rank between 0 and 10, based on its degree of fidelity to a range of synecological parameters (Oldham et al. 1995). Synecology is the study of the structure, development, and distribution of ecological communities. Species ranked between 0 and 3 are found in a variety of plant communities, including disturbed sites. Species ranked between 4 and 6 are those associated with a specific plant community, but which can tolerate moderate disturbance. Species ranked from 7 to 8 are found in plant communities in an advanced stage of succession with minor disturbance. Plants with a ranking of 9 or 10 have high degrees of fidelity to a narrow range of synecological factors. The average CC per plot is shown on Figure 22. The highest CC value in 2013 was found in Plot 4, which is within a white-cedar – hardwood swamp (SWMM1-1). Plot 4 had an average CC value of 4.87 in 2013 and has consistently been among the highest average CC values since 2006. Plot 7 (also within white cedar – mixed swamp) has shown the highest average CC values since 2010 but fell slightly to 4.76 in 2013 from 4.95 in 2012 and a high value of 5.40 in 2010. As 8 vegetation species in Plot 7 have a CC value of 6 or 7, the plot remains relatively rich with a diversity of wetland species and limited establishment of non-native species. Plot 1 (slender willow thicket swamp – SWTM3-3) and Plot 3 (sugar maple forest – FODM6) also showed high CC values in 2013 at 4.10 and 4.40 respectively. The lowest average CC values continue to be found in Plot 6, a successional reed canary grass meadow marsh (MAMM1-3). This plot does not contain any tree or shrub cover and has generally shown average CC values between 2.0 and 3.0. Given the proximity of Plot 6 to former agricultural fields the plot contains a relatively high proportion of non-native species which are not assigned a CC value and therefore lower the average CC value for the plot.

In most plots, the average CC value has shown minimal variation between 2006 and 2013. It should be noted that the recording of a single species with an exceptionally high or low CC value (particularly within a plot containing a relatively small number of species) can influence average CC values greatly. The decrease in average CC values in Plot 5 may be attributed to this factor. It is believed that the variation being documented within the CC continues to be largely a result of natural fluctuations within the system including annual climate fluctuations, succession and seed dispersal and establishment.

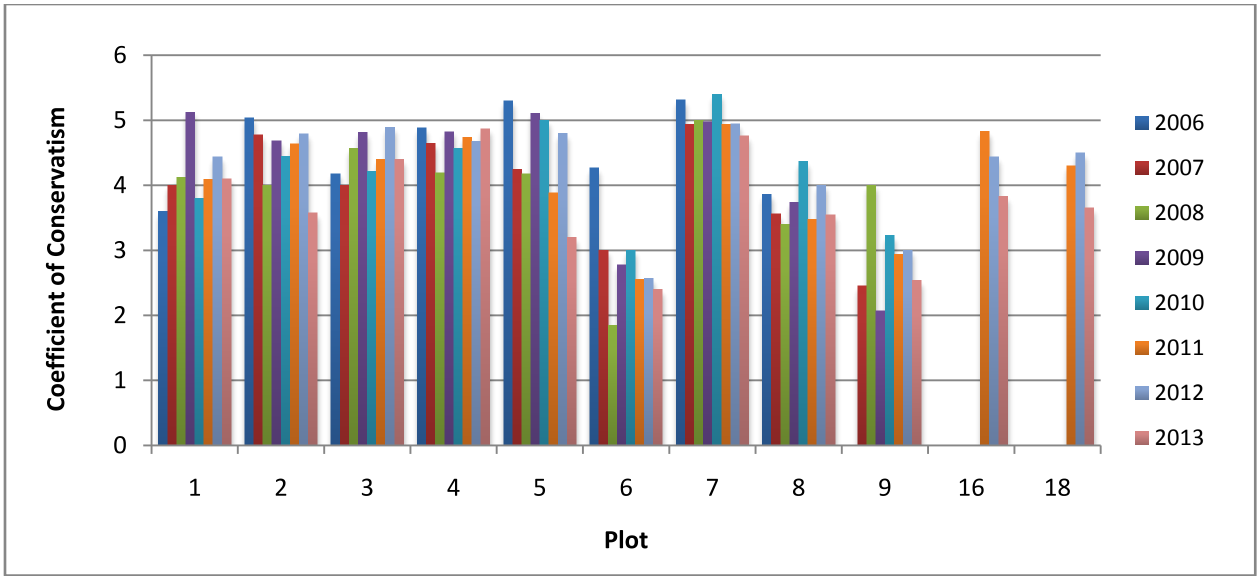

Figure 22. Coefficient of Conservatism by Plot 2006 - 2013

<u>Natural Area Index</u>

The NAI, or floristic quality index, allows the objective comparison of two or more natural areas or vegetation types (Oldham et al. 1995). The NAI is calculated by multiplying the average CC value by the square root of the total number of *native* species. Whereas the abundance and frequency of species can fluctuate greatly by season and year, the NAI is more stable and offers a more accurate picture. The NAI for each plot is shown on Figure 23.

The Ministry of Natural Resources (MNR) reports that natural areas with NAI values of over 35 are considered significant at the provincial level (Wilhelm and Ladd 1988 *in* MNR 1994). For comparison, an old successional field may score as low as <5 (Andreas et al. 2002). None of the plots within the HCBP score a value of 35 or higher. In 2013, three of the 11 vegetation monitoring plots showed slight increases in NAI over 2012 values; however values are still generally lower than in previous years. In 2012, the highest NAI value of 24.27 was found in Plot 7 (white-cedar – hardwood swamp – SWMM1-1), which is an increase from 2012 and suggests a return to pre-2012 values such as 29.20 in 2011 and 32.40 in 2010. As discussed above for CW and CC values, the addition or subtraction of a few species can have great bearing on the overall NAI value. A number of factors will influence the parameters of the NAI equation (average CC and number of native species). Some factors include plant senescence or mortality due to drought (i.e. 2012), and the observation of species which may have been overlooked in the past such as the prevalent non-native tall fescue (*Festucaarundinacea*) first observed in 2013 but very likely present in previous years.

The lowest NAI values have been observed consistently in Plot 6, a reed canary grass meadow marsh, and Plot 9, a cattail marsh. In 2013 these plots had NAI values of 10.73 and 9.15 respectively. Plot 16 has shown a decrease in NAI values over the three years of monitoring, falling to 9.39 in 2013 from 13.32 in 2012 and 18.08 in 2011. It is likely that the exceptionally dry spring in 2012 will have lingering effects on vegetation diversity and cover, in particular within typically wet plots where plant mortality likely occurred.

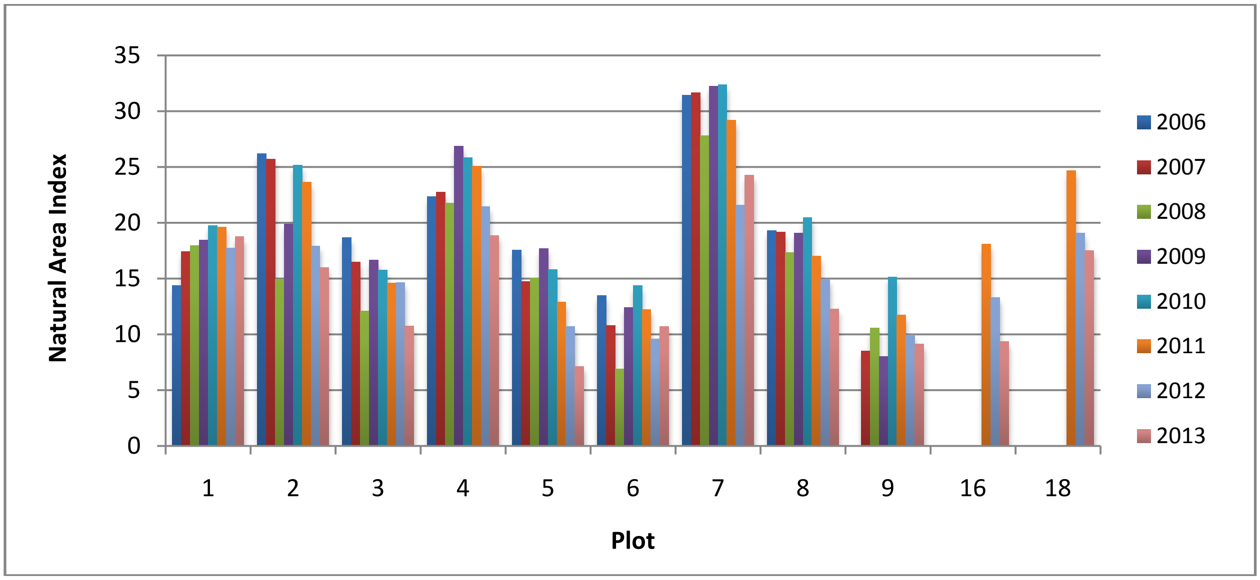

Figure 23. Natural Area Index by Plot 2006 – 2013

2.6.1.2 Non-Native Species

The number of non-native species found in each plot is compared on Figure 24. A total of 16 non-native species were recorded within vegetation plots in 2013. Non-native species were recorded in all plots during the 2013 monitoring with the exception of Plot 5 (which was limited to 5 native species in total). The greatest number of non-native species was recorded in Plot 6, with 10 species documented. Thisplot had 11 non-native species in 2011 and 2012, with 15 non-native species observed in 2010. In general, the same aggressive non-native species have been observed between 2006 and 2013. Situated within a successional reed canary grass meadow marsh, Plot 6 has consistently contained a high number of non-native species due to historic disturbance (human disturbance from ATV's/machinery during pre-construction monitoring year) and close proximity to the previous agricultural land use.

The non-native species observed in 2013 do not represent any significant introductions or reductions of aggressive non-native species. Plot 2 has shown an increase in non-native species while Plot 9 has shown a decrease. In general, those species with weediness values of 2 or 3 tend to be present year after year, while less invasive species with a value of 1 are present intermittently and often in low numbers.

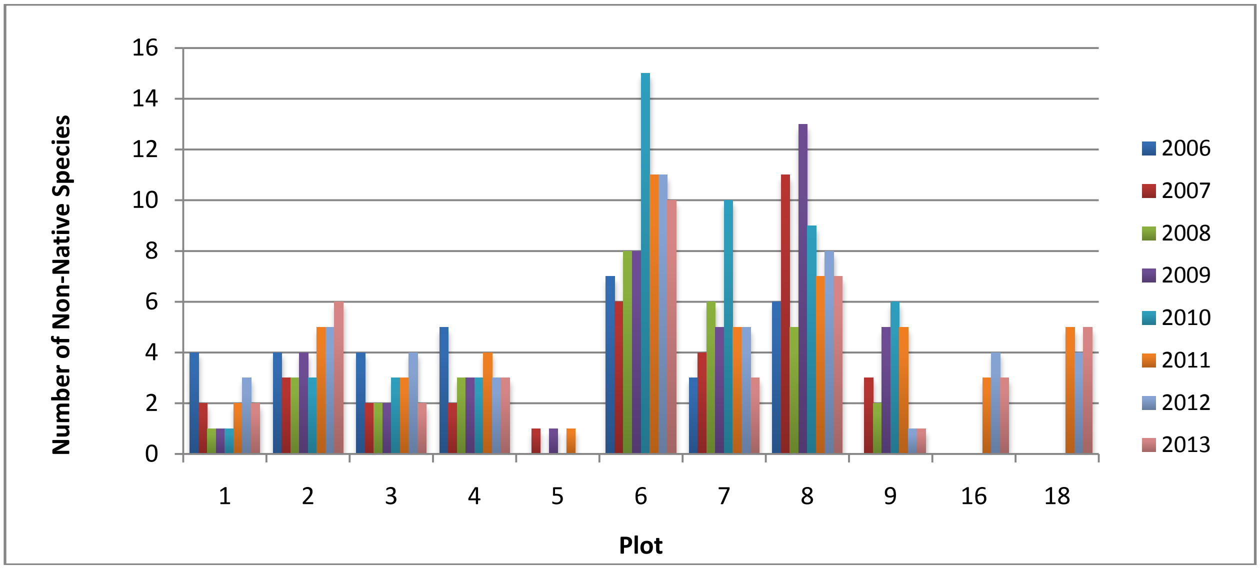

Figure 24. Non-Native Species by Plot 2006 - 2013

Between 2006 and 2012, 28 other non-native species were recorded that were not observed during the 2013 surveys. This fluctuation suggests that some non-native species may only establish for a single season before ecosystem resilience, site conditions (including drought or flooding), or a combination of both suppress the species from establishing within the plots permanently. Tall fescue was documented within the subject property for the first time in 2013 in Plot 6. This perennial non-native species has a weediness value of -1 and often does not produce an inflorescence making it easy to overlook and difficult to identify from other cold season grasses such as orchard grass (*Dactylisglomerata*). It is likely that this species has been present within the vicinity of Plot 6 for some time and was overlooked or identified as "grass species" in previous monitoring years. Tall fescue is often used in lawn seed mixes and can be found in many urban areas in Southern Ontario. Although persistent, tall fescue is not an aggressive species and does not pose a threat to the native species diversity of meadow and marsh habitats within the project area.

Certain non-native species are considered particularly invasive, and are given a score of ‘-3’ on a weediness scale ranging from ‘-1’ to ‘-3’. The invasive species found within the HCBP vegetation monitoring plots include fivedifferent types of shrubs (three species with a weediness value of -3) and 11 herbaceous species (all species with a weediness value of -2 or -1).Non-native species observed in each monitoring year is provided in the 2013 terrestrial and wetland monitoring report (Appendix IV).

Garlic mustard (*Alliariapetiolata*) was only recorded from Plot 18 during the 2011 monitoring year, and was not recorded within any of the plots in 2012 or 2013. Purple loosestrife (*Lythrumsalicaria*) (weediness value of -3) was observed within the subject property for the first time (Plot 1 in 2012) but was not observed again during 2013 surveys. Common buckthorn (*Rhamnuscathartica*) is the most widely dispersed non-native plant within the monitoring plots with glossy buckthorn (*Rhamnusfrangula*) also found in a number of plots with mesic to wet soils. Both species are tolerant of shading and fruiting specimens tend to be most common at the edge of wooded features where they receive ample sunlight. During vegetation surveys some species were only identified to genus as the identifying traits of the plant may not have been apparent at the time of the survey. These include avens species (*Geum sp.*), sedge species (*Carex sp.*), smartweed species (*Polygonum sp.*) and unidentifiable grass species. These species were included in the overall species count for the plot but were not included in the non-native species totals as a positive identification of the species was not possible.

2.6.1.3 Herbaceous Inventory

A total of 110 species of herbaceous plants were observed during the plot-based vegetation monitoring that was conducted in 2013. A total of 10 herbaceous species were recorded for the first time in 2013 including six native species. Notable newly documented herbaceous species include swamp thistle (*Cirsiummuticum*) (CC 8), fen twayblade (*Liparisloeselii*) (CC 5) and bog goldenrod (*Solidagouliginosa*) (CC 9). All three of these species have wetland affinities and are indicators of rich, intact swamp habitats. Observations of these species in Plot 2, 4 and 7 respectively, consisted of one to several individuals within the plot.

2.6.1.4 Shrub Inventory

The number of shrub species found within each monitoring plot and their approximate percent cover was recorded. In 2013, 21 shrub species were recorded. This number has varied over the monitoring years from a low of 15 species in 2007, 2008, and 2009. Shrub species which were observed for the first time in 2013 included gray dogwood (*Cornusfoemina*) (Plot 9), woodbine (*Parthenocissusvitacea*) (Plot 2, 4, 16 and 18) and western poison ivy (*Toxicodendronrydbergii*) (Plot 18). Gray dogwood is a common early successional species which can be found in fallow fields and along woodland edges, it is aggressively clonal and forms dense thickets. Both woodbine and western poison ivy are vine species which have likely spread into the vegetation plot from adjacent areas where they have been established for some time, or through seed dispersal by wildlife.

2.6.1.5 Tree Inventory

Results from 2013 are provided in the 2013terrestrial and wetland monitoring report (Appendix V). Similar to previous monitoring years, trees are absent from Plots 1, 6, and 9. The dominant tree species found within each plot did not change from the data obtained in previous years. No notable changes were observed in tree species composition or tree health within any of the monitoring plots between 2013 and previous years. Given the limited number of ash trees within vegetation monitoring plots it is difficult to observe any large-scale decline of ash trees due to Emerald Ash Borer (EAB) (*Agrilusplanipennis*). No signs of EAB were detected within the monitoring plots in 2013.

2.6.2 Breeding Birds

A total of 50 species of birds were observed during the breeding bird monitoring that was conducted in 2013. Birds observed while conducting other field surveys (i.e. construction inspections) and transects between breeding bird stations were also recorded as incidentals. Of the 50 species observed, 21 exhibited possible breeding evidence, 24 exhibited probable, three were confirmed, and two showed no breeding evidence.

The most abundant species observed during 2013 surveys was song sparrow (*Melospizamelodia*), making up 13% of the observations during breeding bird point counts. This was followed by American robin (*Turdusmigratorius*) with 11% and red-winged blackbird (*Agelaiusphoeniceus*) at 10%. These species were also the most abundant in 2010, 2011 and 2012. Figure 25 represents the nine most abundant species observed in 2013, with all other birds observed less frequently lumped together in ‘other’.

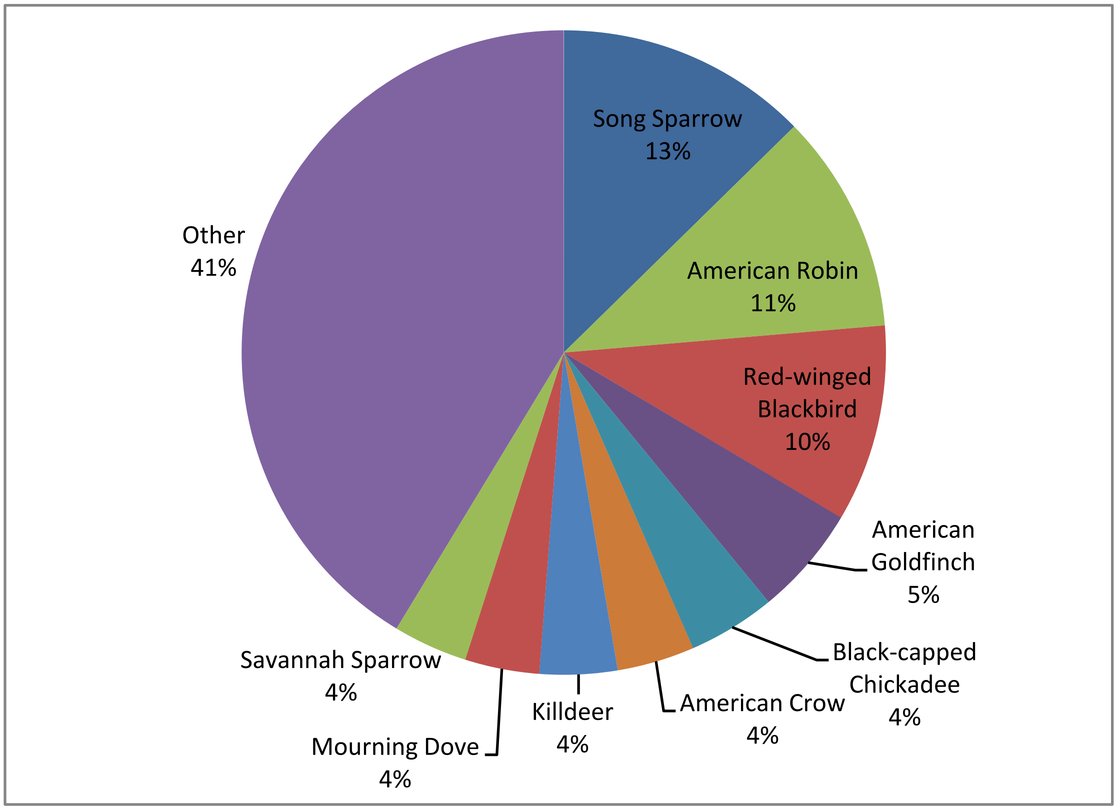

Figure 25. Most Abundant Bird Species Observed in 2013

2.6.2.1 Breeding Bird Species Diversity

In general, the diversity of bird species at each plot in 2013 was average to higher than average with six of 13 plots showing the highest diversity to-date across all monitoring years. As indicated on Figure 26, data trends show a steady increase in species diversity or a relatively consistent number of species.

The 2012 monitoring report (NRSI 2013b) had identified a consistent decrease in species diversity in Plot 11 between the 2009 and 2012 monitoring years and this change was attributed to the grading and servicing around the Heritage Maple Grove in Phase 2. Breeding bird surveys in 2013 showed a marked increase in species diversity from 13 species in 2012 to 22 in 2013. While natural fluctuations must be taken into account, the limited construction activity in Phase 2 in 2013 coupled with a notable increase in species diversity may be an indication of the impact of construction on breeding bird presence.

Since monitoring of Plot 16 began in 2011, species diversity has fluctuated with a notably low diversity in 2012. Although diversity in 2013 showed some rebound, the on-going construction of buildings in the vicinity of Plot 16 will likely maintain the level of human disturbance in the area for several more years. It is anticipated that once construction has subsided within the immediate area surrounding Plot 16, bird diversity may increase with lower noise levels and the establishment of edge plantings. Additionally, the naturalizing meadow habitat between Plot 16 and Plot 18 has likely increased the availability of forage seeds and nesting habitat for a number of bird species.

Within Phase 3, Plot 19 and Plot 20 maintained a high diversity of grassland bird species in 2013 with 22 and 21 species respectively. Song sparrow and savannah sparrow (*Passerculussandwichensis*) were relatively abundant within the open country plots in Phase 3 and showed confirmed and probable breeding evidence respectively. In Plot 20, Bobolink (*Dolichonyxoryzivorus*) and eastern meadowlark (*Sturnella magna*) both displayed probable breeding evidence in 2013 with as many as four individuals of each species recorded on a single survey date. Both species are listed as Threatened provincially and nationally (OMNR 2013b, COSEWIC 2013) and have been recorded in Plot 20 in 2010 and 2011 showing possible breeding evidence.

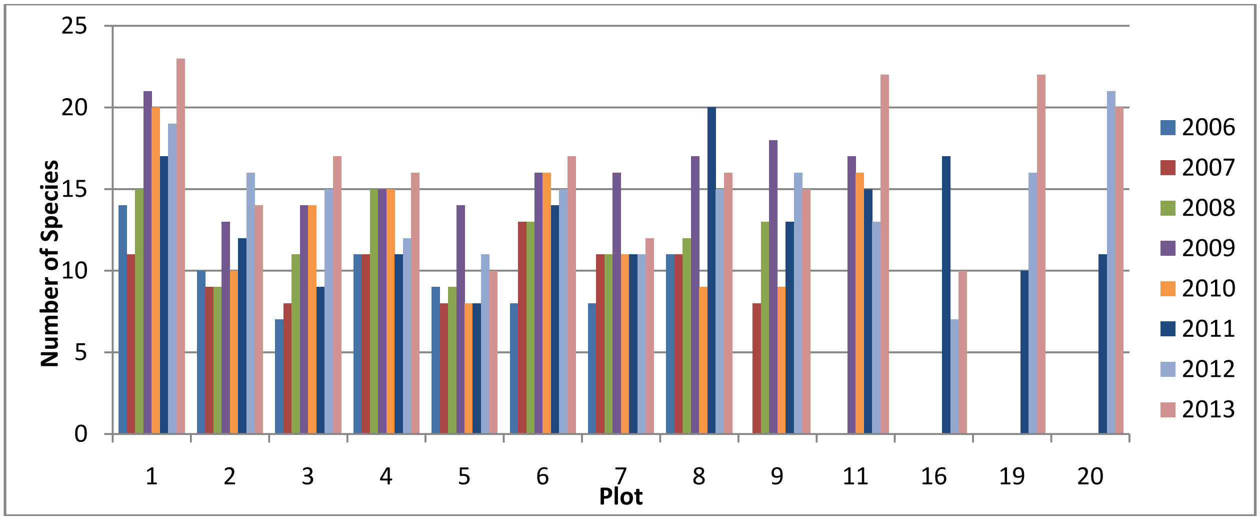

Figure 26. Breeding Bird Species Diversity 2006 – 2013

2.6.2.2 Breeding Bird Abundance

The breeding bird abundance (the number of individual birds) since 2006 is shown on Figure 27.Data collected in 2013 indicates that eight of the 13 plots showed the highest recorded abundance of birds since monitoring began in 2006. In general the 2013 abundance reflects the 2012 abundance on a plot-by-plot basis with notable increases in bird abundance in Plots 3, 4, 11 and 19. No notable decreases were observed between 2012 and 2013 and long-term trends appear to show steady numbers or slight increases in abundance between 2006 and 2013. Those plots which showed a notable increase in bird abundance in 2013 were generally comprised of a variety of common species including black-capped chickadee (*Poecileatricapillus*), song sparrow, European starling (*Sturnus vulgaris*) and American goldfinch (*Spinustristis*), with no one species overly abundant. With the exception of 14 red-winged blackbirdsrecorded in Plot 6 during the June 20 survey, bird abundance was eightindividuals or fewer for any given species on either survey date. Spikes in bird abundance have been observed in past monitoring years due to large flocks of a single species which have included red-winged blackbirds in Plot 6 in 2006 and Canada goose (*Brantacanadensis*) in Plot 9 in 2007. Consistent with 2012 findings, Plot 1 and Plot 6 showed the highest numbers of birds in 2013 at 70 and 64 individuals for each station respectively. These plots are likely to yield higher bird abundance due to a combination of treed and open upland and wetland habitats present within the immediate survey area. The lowest bird abundance occurred at Plot 5 with 24 birds observed, down from 27 species in 2012. Consistently low in bird abundance, Plot 5 is also limited in plant species diversity with very limited herbaceous groundcover below a dense white cedar canopy.

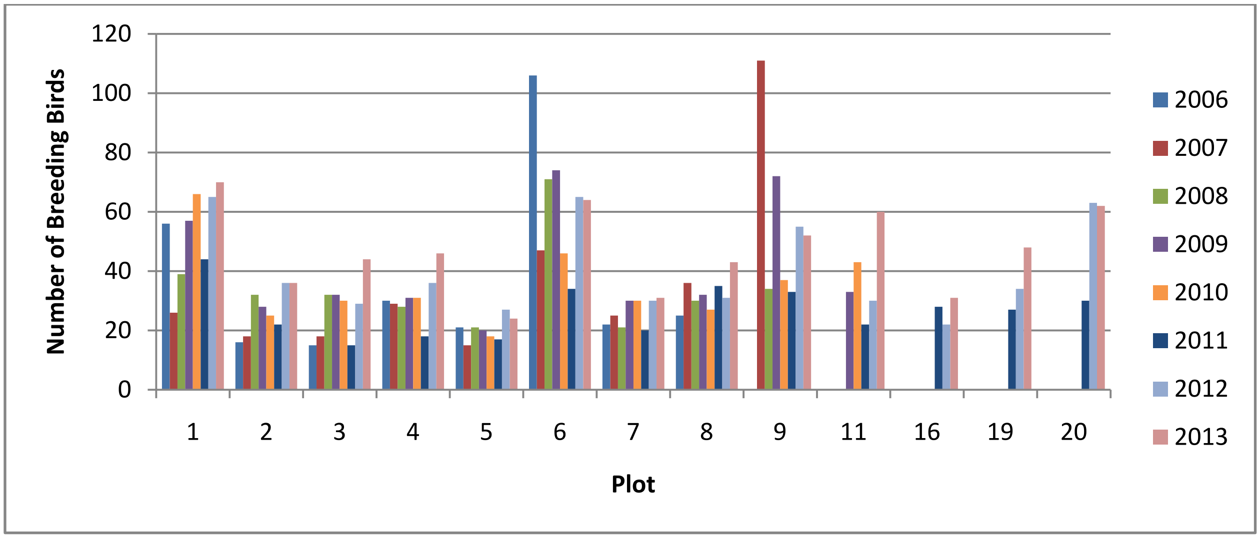

Figure 27. Breeding Bird Abundance 2006 - 2013

2.6.2.3 Significant Species

NRSI observed three species that are considered Threatened federally and provincially (COSEWIC 2013, OMNR 2013b): barn swallow (*Hirundorustica*), bobolink, and eastern meadowlark. Bobolink was listed as Threatened by COSEWIC and COSARRO in 2010, while barn swallow and eastern meadowlark were up-listed in 2011. Bobolink requires large, open expansive grasslands (>50ha) with dense ground cover; hayfields, meadows or fallow fields; marshes (OMNR 2000). This species was observed showing probable breeding evidence in 2013. Bobolinks were observed in Plots 9 and 20. Two singing males were observed at Plot 9 on June 7 while a single singing male was observed at Plot 9 on June 20 (probable breeding evidence). Although Plot 9 exists as cattail marsh (MASM2-1), breeding bird plots include a radius of 100m which included hayfield and cornfield adjacent to Plot 9 in 2013. At Plot 20, fourbobolink were recorded on June 7, including a pair which denotes probable breeding evidence. Three singing males were observed at Plot 20 on the second breeding bird visit on June 20. Incidental observations of bobolink were also made outside of the breeding bird survey period.Barn swallows are found in farmlands and rural areas, and generally use buildings (such as barns) or other man-made structures for nesting. They are often found foraging in open country near water. In 2013, this species was recorded showing possible breeding evidence in Plots 1 and 19. Observations of individuals which did not exhibit any breeding evidence were noted at Plots 8, 11 and 20. The farmhouse which exists near Plot 20 may provide suitable nesting habitat for barn swallow; however no breeding evidence was observed at Plot 20 in 2013. Barn swallow may also be nesting outside of the subject property in barns alongForestell Road or Downey Road and utilizing the subject property for foraging habitat. Eastern meadowlark requires grassy meadows, farmland, pastures or hayfields at least 10ha in size (OMNR 2000a). Suitable habitat for these open country birds is found within the southwest portion of the subject property (Phase 3) as well as within the retained open meadow habitat associated with Plot 19 (see Map 1). This species was recorded as showing probable breeding evidence in 2013. It was observed within Plots 1, 6, 9 and 11 showing possible breeding evidence and at Plot 20 showing probable breeding evidence. During the June 7 breeding bird survey, 4 singing males were observed at Plot 20 while 2 singing males were observed on June 20 denoting probable breeding evidence. This species has been observed within the subject property each year since 2007 and suitable habitat for nesting and foraging existswithin the fields that have now been left fallow for a number of years, particularly within Phase 3 lands.

Two bird species were observed in 2013 which are listed federally but not provincially. Eastern wood-pewee (*Contopusvirens*) is listed as Special Concern and wood thrush (*Hylocichlamustelina*) is listed as Threatened (COSEWIC 2013).Habitat preferences for these species can be found in the complete 2013terrestrial and wetland monitoring report (Appendix V). That report also provides a list of the locally significant bird species that were observed by NRSI in 2013.

A total of 17 bird species were observed which are considered significant within the City of Guelph (Dougan& Associates 2009). Of these 17 species, seven showed probable breeding evidence, seven showed possible breeding evidence, and three did not show any breeding evidence (i.e. flying over habitat). Significant species within Wellington County which had not been recorded within the subject property previously included cliff swallow, grasshopper sparrow and red-bellied woodpecker. Both grasshopper sparrow and red-bellied woodpecker showed possible breeding evidence in 2013.

2.6.3 Amphibians

Calling anuran species were recorded at 10 of 16 monitoring plots in 2013. Plots 1, 6, 12 and 19 all recorded three species of anuran. In previous monitoring years three plots have recorded a high of four species. Gray treefrog was recorded at Plot 13 in 2013 and constitutes the first calling amphibian recorded in this plot since monitoring began in 2006. This signifies that all anuran stations have now had at least one species of calling amphibian recorded over eight seasons of monitoring. No species were observed in Plots 2, 4, 8, 10, 14 and 17. These plots were often noted to be dry on one or multiple survey dates.

Four amphibian species were recorded during evening call count surveys in 2013; American toad (*Bufoamericanus*), spring peeper (*Pseudacris crucifer crucifer*), wood frog (*Lithobates sylvatica*) and gray treefrog (*Hyla versicolor*). Species recorded during surveys have fluctuated over the eight-year monitoring period, with as many as six species recorded during 2009 surveys and none recorded during the first preconstruction monitoring year (2006). The four amphibian species recorded calling in 2013 is average among species numbers recorded in previous years. It should be noted that green frog (*Rana clamitansmelanota*) and northern leopard frog (*Rana pipiens*) were recorded during the Laird Road wildlife culvert surveys conducted in spring 2013; however these species were not recorded during calling amphibian surveys.

Spring peeperwas the most abundant and most widely distributed species, being recorded at seven plots in 2013. The highest numbers were recorded at Plot 1, Plot 12, and Plot 16 where full choruses were heard (many individuals; too many to count).This species showed an increase in abundance similar to what was recorded between 2007 and 2011 following a very low year in 2012.

American toads were not recorded within the 100m radius of any anuran monitoring station in 2013. Previous monitoring years have shown fluctuations in the abundance and dispersal of this species ranging from a full chorus and observed at three stations to years where no calls were recorded during surveys (2010). American toads were observed incidentally, either as direct observations or calling from within stormwater management ponds which are outside of point count stations.

Gray treefrogwas the second most widely distributed species in 2013 at six of 16 stations (Plots 1, 7, 12, 13, 16 and 18). Gray treefrog had not previously been recorded at four of these stations. Although generally recorded in low numbers with limited distribution, several monitoring stations recorded high numbers of calling individuals in 2013. Estimates of abundance noted 27 calling individuals. Gray treefrog abundance and distribution in 2013 was similar to that of spring peeper (consistently the most abundant and widely distributed species), suggesting increases in the population and range of the species within the subject property. This abundance in 2013 may be attributed to warm temperatures and ample rainfall through the late spring and early summer when the species is breeding.

Wood frog abundance has fluctuated more than any other anuran species over the course of eight seasons of monitoring with years of abundant calls often followed by years without any recorded individuals. The species was recorded in full chorus at Plot 6 and Plot 16 in 2013, whereas calls in previous years have tended to be call code 1 and 2, with variability in the location of calling individuals. In 2011, a total of 31 wood frogs were recorded from nine different plots representing the highest number of individuals between 2009 and 2013. Wood frog numbers in 2013 were distributed among more plots and more abundant than numbers recorded during 2012 surveys.Despite cold temperatures in March and April, wood frogs are known to be tolerant of very cold temperatures. This species breeds in the early spring and was recorded at five stations on the April 16, 2013 survey date.

In addition to those anuran species listed above, wildlife culvert surveys conducted along Laird Road during the spring of 2013 identified green frogs and northern leopard frogs. Neither of these species was heard calling during calling amphibian surveys. Both species have been recorded calling in limited numbers over the past eight seasons and show a preference for breeding habitats located outside of the core PSW feature.No pickerel frogs (*Rana palustris*) or western chorus frogs (*Pseudacristriseriata*) were observed in 2013, either during call counts or incidentally. Both of these species have been recorded intermittently within the subject property in previous years, with a call code of 1 or 2 and in low numbers.

The 2013terrestrial and wetland monitoring report (Appendix V) provides detailed information on the ambient air temperature, water temperature, and pH ranges for each of the field visits in 2013.

3.0 Summary of Thresholds

Thresholds have been developed for each component of the Hanlon Creek Business Park Monitoring Program. Each threshold is described within the*HCBP Consolidated Monitoring Program* (NRSI 2010) and is listed in Table 7.

Table 7.Summary of Thresholds by Monitoring Component

Component	Threshold	Exceedance in 2013 (Yes/No, stations)
Groundwater	A specific quantitative threshold is not used. However, groundwater elevations that increase above previously observed seasonal high levels or decline below previously observed seasonal low levels, without an obvious relationship to precipitation, will be identified as observations of concern. Similarly, groundwater quality that differs from previous ranges in parameters, and/or indicates an upward trend, will be identified as observations of concern.	No
Surface Water	1. Any single temperature exceedance of 22°C requires analysis in the annual consolidated monitoring report.	Yes, at HC-A(04), HC-A(06), HC-A(08), HC-A(09), HC-A(10), HC-A(11), HC-A(12), HC-A(13), HC-A(14), SR-1(01)
	2. Any single temperature exceedance of 24°C triggers the Rapid Assessment and Action Protocol.	Yes, at HC-A(04), HC-A(06), HC-A(09), HC-A(10), HC-A(12), HC-A(13), HC-A(14), SR-1(01)
Fish	1. A 50% change in the number of taxa represents a potential decline in the suitability of the habitat for brook trout. Because coldwater fish communities typically have a lower species diversity, an increase in species diversity may represent a negative change in relation to the brook trout management objective. Specifically, the warm-water fish community may increase in species richness as a result of warmer water temperatures, which indicates that the habitat is	No

Component	Threshold	Exceedance in 2013 (Yes/No, stations)
	becoming less suitable for brook trout. A decrease in species diversity may also represent a negative change in the suitability of the habitat for brook trout, likely attributable to some cause other than water temperature.	
	2. A 50% reduction in the number of fish captured represents a potential decline in the fish community resulting from habitat impacts. However, it may also represent an improvement in habitat suitability for brook trout based on temperature changes, as discussed above.	No
Benthic Invertebrates	1. For the Percent Model Affinity (PMA) analysis, the threshold is an "Impact" determination at a station for 2 consecutive years following 2 consecutive years where the determination was "No Impact" at that station.	Yes, at BTH-003, BTH-004
	2. For Total Taxonomic Richness, the threshold is a 50% decline in the total number of taxa at a station, as compared to the results from the previous year.	Yes, at BTH-005
	3. For EPT Taxonomic Richness, the threshold is a 50% decline in the number of EPT taxa at a station, as compared to the average results from the previous 2 years.	Yes, at BTH-001
Vegetation and Soils	1. A change in herbaceous cover by more than 25%.	Yes, at Plot 2, Plot 3
	2. A change in species diversity by more than 25%.	Yes, at Plot 1, Plot 2, Plot 5, Plot 6, Plot 9
	3. A change in canopy cover by more than 25%.	No
Breeding Birds	1. A negative change in species diversity (number of species) by more than 25%.	No
	2. A negative change in the breeding bird abundance (number of individuals birds) by more than 25%.	No
Amphibians	1. Adecrease in species diversity (number of species) by more than 2 species.	No
	2. A change in species abundance measured by a decrease in two call codes.	Yes, at Plot 4 Plot 16, Plot 18

4.0 Rapid Assessment and Action Protocol

In 2011 a Rapid Assessment and Action Protocol (RAAP) was implemented as a response protocol for when thresholds are exceeded or when other unexpected environmental issues arise. A six-person committee was set which included a primary and an alternate designated for each represented group (City of Guelph, GRCA, and Monitoring Team). Whenever there was a RAAP event, all six people were contacted via email, and a meeting was scheduled. The list of designated persons for 2013 is shown in Table 8.

Table 8. List of Designated Persons

Affiliation	Name
Monitoring Team (AECOM)	Nicole Weber
Monitoring Team (NRSI)	Andrew Schiedel
City of Guelph	ArunHindupur
City of Guelph	AdèleLabbé
GRCA	John Palmer
GRCA	Nigel Ward

The specific thresholds that require rapid response are the 22.0°C and 24.0°C stream temperature thresholds, and the turbidity threshold which was initially set at 10 NTU in the Consolidated Monitoring Program guidance document (NRSI 2010). These targets were set with the primary goal of maintaining brook trout habitat within the Hanlon Creek tributaries. To determine when temperatures or turbidity exceed these thresholds, a telemetry system was implemented at four stations within the site to monitor temperature, turbidity and depth. This system notified the monitoring staff when there was an exceedance, triggering the RAAP.In addition, any on-site observations of immediate problems, such as sediment observed entering a wetland or watercourse during a rainfall event, one or more of the designated persons should be contacted. If a RAAP is triggered, the basic steps are:

1. After the exceedance/event occurs the monitoring staff member, inspector or notified person will contact the designated persons immediately.
2. The designated persons must meet/conference call within 48 hrs.
3. Notification and corrective actions must be proposed within three business days.
4. Report should be produced.
5. This report should be included in the consolidated monitoring report.

Section 4.1 provides a detailed account of the meetings that occurred as a result of threshold exceedances in 2013.

4.1 Chronology of Events

The following summary is based on the correspondence and meeting minutes of the RAAP committee found in Appendix VI.

An email was circulated to the RAAP group by AECOM on March 4, 2013 which outlined an internal discussion that had been held by AECOM regarding the function of the outlet weir on SWM Pond 4 as it related to groundwater levels, and pond and groundwater temperatures. The email recommended that the weir should be returned to its original design elevation to allow the pond water elevation and vegetation to establish in the design state and to allow for monitoring of temperatures within the pond in the design state throughout 2013. In 2012 the weir was raised from an elevation of 325.0 to 325.3masl in order to counteract adjacent groundwater elevations that were causing groundwater to flow through the un-lined pond (NRSI 2013b). Confirmation was requested from the City of Guelph and GRCA to proceed with this. A reply was sent by the GRCA indicating that based on experience and knowledge gained in 2012, the level of the weir would need to be raised again during warmer weather to counteract adjacent groundwater elevations that would otherwise cause continuous flow through the pond. AECOM responded on April 18, indicating that they had conducted a site visit with the City of Guelph to review the function of the outlet structure and recommended that the entire weir be taken out and replaced with a removable weir to the original design elevation, which could be adjusted as necessary.

A response was sent by the GRCA on April 29 along with another email providing additional insight on April 30. GRCA mentioned that they had been on site on April 11 and observed water flowing from the pond and through the trench into the rock lined channel and out letting into Tributary A, as the trench design allowed.A detailed account of these observations is provided in these emails (Appendix VI). Following observations, GRCA mentioned that it may be worth considering plugging the perforated pipes, at opposite ends to each other, in order to prevent end to end through-flow by any one pipe.GRCA's follow-up email sent on April 30 discounted the potential plugging of the pipes at opposite ends and instead proposed that it may be better to consider plugging both perforated pipes at the creek end. This would maximize the amount of time the water is in contact with the pipes before flowing through perforations into surrounding void spaces, transferring heat to the stones, and mixing with cooler groundwater before entering Tributary A. It was also mentioned in that email that due to the marginal cooling by the trench in 2012 all feasible avenues for improving performance would need to be considered.A response from AECOM on June 13 indicated that in 2012 the cooling trench did provide a moderating effect on temperature effluents compared to in pond temperatures as outlet temperatures were always below the pond bottom draw outlet temperatures during daytime hours. It was concluded that the weir would be left in the raised position (325.3masl) for the time being and impacts would be monitored closely over the next month to review temperature and flow impacts to the creek. In addition, the growth of the planted wetland vegetation and vines over the cooling trench were continuing to be monitored. No additional actions were recommended following this discussion.

On May 31, 2013 an email was circulated to the RAAP group by AECOM, and a conference call was held to discuss a temperature exceedance of 24.0°C. This exceedance was observed by AECOM at the most downstream station (HC-A(14), which is located at the northern extent of the HCBP lands in Hanlon Creek Tributary A and immediately downstream of SWM Pond 2. It was indicated that none of the other monitoring stations had reached 20°C. A memo was prepared by AECOMand circulated to the RAAP group on June 29. Thismemo summarized the conference call that was held on May 31 and outlined the exceedance at HC-A(14) as well as potential impacts of the stormwater management ponds upstream of the monitoring station on the exceedance. Data show that the 24°C threshold was exceeded by less than a degree for a few hours in the afternoon on the day of May 31. AECOM suggested that a field visit be conducted to the site in the following week to download temperature logger data and determine whether the ponds might be implicated in the temperature exceedance. This field visit was conducted on June 4, which included the download of all level/temperature loggers from SWM ponds 1 and 2 as well as from creek sites HC-A(12) and HC-A(13). This was compared to temperature records from telemetry stations HC-A(14), HC-A(11), and HC-A(06), which were retrieved online. During the visit on June 4, SWM Pond 2 was not observed to be flowing while Pond 1 was flowing. Station HC-A(14) is located immediately downstream of the Pond 2 outflow. Graphs show that on May 31, the recorded water level was lower than on June 4 and, therefore, was not likely discharging, in which case Pond 2 did not contribute to the HC-A(14) exceedance. As noted, Pond 1 was observed to be flowing to the creek on June 4. There was a potential thatPond 1 could have contributed to the exceedance due to the minor flows from the pond, combined with solar heating and the lack of groundwater discharge upstream from HC-A(14). However, since temperature exceedances were not uncommon throughout this shallow, open reach of Tributary A prior to construction, the exceedance was not attributed to the SWM ponds or construction-related activities. In addition, air temperatures were noted to be elevated on May 31 around 28 or 29°C, which would have had an impact on the overall stream temperatures on that date. All other telemetry stations remained below the 24.0°C threshold during this time. It was determined that no additional actions were required for the exceedances experienced at HC-A(14).The memo did state that the efficacy of the Pond 1 cooling trenches should continue to be monitored to determine whether improvements to one or both of the cooling trenches would be appropriate.The memo also identified several other instances between June 23 and June 26 where temperature exceedances were noted for HC-A(14). The air temperatures on June 23 and June 24 were noted to be much higher than the recorded water temperatures and were identified as the main contributors to the exceedances.

An email from NRSI regarding the status of aquatic vegetation within SWM Pond 4 and the plantings along its cooling trench was circulated to the RAAP group by NRSI on July 8, 2013. This email indicated that aquatic and riparian vegetation had begun to establish itself, mainly along the northern and northeast edges of the pond but in other areas as well. This included the emergence of species that had been planted in the fall of 2012 such as pondweed, broad-leaved arrowhead, duckweed, and water lily, in addition to small willows, which were beginning to grow up into the already established cattails. It was noted, however that the larger area of open water throughout the deeper areas of the pond was still largely void of vegetation.

In regards to the cooling trench, NRSI observed vegetation emerging throughout the rocks along the east end of the trench, and although the planted vines were growing slower than expected the vegetation that was establishing would likely progress well over the following years. NRSI indicated that the vegetation was not expected to provide full shade and be the ‘cooling’ answer within its first year of planting. It was further explained that it can take several years (3+) for vegetation to become established and become mature in order to function as intended. A follow-up email was circulated to the RAAP group by NRSI on July 19 following the request for photographs of the SWM Pond 4 vegetation. This email included several pictures of the state of the establishing vegetation within and around the pond as well as at the cooling trench. The email mentioned that the consulting team, including the landscaping company that was responsible for the wetland planting would be discussing next steps to ensure the establishment of the vegetation within the open water areas and along the cooling trench. This email prompted responses from the RAAP group and a discussion regarding the state of the cooling trench and potential options to expedite the establishment of vegetation. AECOM indicated that they would be on site the following week to check the loggers at pond 4 and station 4 to make sure that water was not flowing from the pond. The City of Guelph also indicated that checking the groundwater temperatures would be a good idea. Water had been observed by NRSI when the vegetation pictures were taken, however this was believed to be groundwater that was making its way into the trench, but not through the pond. AECOM wondered if it was reasonable to plant additional trees on either side of the trench near its outlet to the stream, which would be effective at shading the trench in the afternoon. NRSI responded to this on July 23, mentioning that there was little room to plant additional trees on the north and south sides of the trench, and although there may be space for some shrubs to be planted, they would provide little overall benefit to the function of shading the trench. Vines and herbaceous species were noted to be the best option to provide additional shade. The GRCA included that intensifying the plantings of mature vines would assist in cooling the trench in the immediate term rather than waiting for the immature plants to colonize. NRSI replied stating that the landscaper was investigating the potential to source mature vines and additional aquatic plant options. The RAAP group would be updated once it was determined what was available.

An additional visit to the site was conducted by NRSI during the week of August 12, 2013. An email was circulated to the RAAP group on August 15 regarding this site visit, which included comparative photographs of the SWM Pond 4 vegetation between 2012 and 2013. NRSI noted that over the course of the month there was a noticeable increase in the establishment of submergent aquatic vegetation, as well as water lily and floating pondweed along the perimeter of the pond. It was also mentioned that floating pondweed was beginning to establish along the silt curtain that crossed the pond and it appeared that submergent vegetation was establishing throughout the open water area. NRSI also looked at the availability of space to plant trees around the cooling trench, but noted that ultimately there would not be enough space for mature trees, in addition to the long period of time the trees would require to grow and reach a point that they would provide benefit for the trench. It was recommended by NRSI that, regarding the vegetation around SWM pond 4, a second year of growth be allowed before planting additional vines along the cooling trench or lilies and pondweed within the SWM pond. No further discussions or actions were taken regarding this.

The RAAP group was initiated on July 16, 2013in response to temperatures exceeding 24.0°C atstation HC-A(14). An email was circulated to the RAAP group by AECOM describing the exceedance and indicated that no conference call was required as the exceedance was most likely attributed to the lack of precipitation over the previous days. AECOM also mentioned that a call would be initiated only in the event that other stations exceed 24.0°C. The RAAP group agreed on this approach and no further actions were required.

The RAAP group was initiated on July 19, 2013 in response to temperatures exceeding 24.0°C at station HC-A(06). It was also mentioned that station HC-A(14) had consistently exceeded 24°C throughout the week for lengthening durations. Air temperatures throughout the week were noted to be high and there was a limited amount of precipitation. An email was circulated to the RAAP group by AECOM to organize a conference call to discuss the exceedance. A call was held between the RAAP members on July 19 to discuss the exceedances at the two stations. No actions were required as the exceedances were most likely a result of high air temperatures and low precipitation.

For a more detailed account of each RAAP meeting and correspondence refer to Appendix VI. Groundwater monitoring results for 2013 are discussed in detail in Sections 2.1 and 2.3 and surface water monitoring results are discussed in Sections 2.2 and 2.3.

5.0 Discussion of Issues

Several issues were identified during the 2013 monitoring season. These were identified based on theexceedances of the various monitoring component thresholds that have been described within the *Hanlon Creek Business Park Consolidated Monitoring Program* (NRSI 2010). Threshold exceedancesare addressed in Section 3.0. Eight issues wereidentified in 2013 and are discussed below.

5.1 Potential Water Temperature Impacts from Stormwater Management Pond 1

In the spring of 2013, elevated water temperatures throughout the downstream portion of Tributary A resulted in exceedances of 24°C atmonitoring stations HC-A(13) and HC-A(14). These stations are both located downstream of the outlets from SWM Pond 1, which exists on the lands to the east of the creek in the northern portion of the study area. The potential factors influencing the elevated water temperatures were discussed by the RAAP group in an attempt to address the exceedances.Several factors are believed to have contributed to the elevated water temperatures throughout the downstream portions of the site. These include climatic conditions and station characteristics as well as potential influences from SWM Pond 1.

Climatic conditions are likely to have had the greatest influence on the temperatures experienced throughout the downstream sections of Tributary A. Surface water monitoring station HC-A(13) is located immediately downstream of the outlet of Pond 1 while HC-A(14) is located at the downstream end of the study site, approximately 150 m upstream of Teal Drive. Both of these stations are quite exposed and exhibit relatively high daily variations in temperature throughout the summer months due to a greater potential for solar radiation. These stations are also considered to be ‘perimeter locations’ since they are located around the perimeter of the core PSW and are considered to be located within a losing reach of Tributary A. Here, flow from the creek exhibits a downward gradient indicating that water is infiltrating from the creek into the groundwater system. Comparatively, throughout the headwater sections of Tributary A and Tributary A1 the creek exhibits an upward gradient, indicating areas of groundwater discharge, where cooler groundwater is entering into the creek from the groundwater system. The recharge characteristics and lack of significant tree cover throughout the northern section of Tributary A mean the creek is more prone to elevated water temperatures as a result of solar radiation. In conjunction with this, the lack of groundwater discharge to the system means that there is no moderating effect to counteract the variations inambient air temperature.

SWM Pond 1 exists on the lands to the east of Tributary A and was designed and built with two cooling trenches. These trenchesreceive water from the pond via a bottom-draw structure before out letting into Tributary A. The temperature at the bottom-draw pond outlet was generally 1.0 to 4.0°C lower (during summer months) than within the pond, indicating that the bottom draw outlet successfully allows for the discharge of the coldest (deepest) water first. Water temperatures were measured at the outlets of each of the two cooling trenches to determine their overall effectiveness. During discharge events one of the two cooling trenches (HC-P1(07))proved to be more effective at lowering water temperatures as it remained at least 2.0°C lower than the discharging water temperature.Initially a cooling effect was observed within the second trench (HC-P1(08)); however as the event continued, the temperature matched and sometimes exceeded the temperature recorded at the pond outfall. With the observations made at HC-P1(08), it is still difficult to determine if the discharge from Pond 1 has an effect on downstream temperatures.

Due to the limited flow events at Pond 1, it is most likely that the flow from HC-P1(08), even after a discharge event, is too low to have a significant impact on downstream temperatures.An exceedance of 24.0°C occurred on May 31 at surface water monitoring station HC-A(14), which is located approximately 200m downstream from Pond 1. Data show that the 24.0°C threshold was exceeded by less than a degree for a few hours in the afternoon on the day of May 31. Water was observed to be discharging from Pond 1to the creek during a follow-up visit on June 4.It was noted that ambient air temperatures around May 31 were elevated to approximately 29.0°C. These elevated air temperatures would have had an impact on the stream temperatures at this location where the channel is known to be relatively shallow and prone to solar radiation heating. Based on the information it was difficult to determine whether the discharging water from Pond 1 contributed to the exceedance downstream.On July 5, 2013 the recorded water temperatures at both cooling trench outlets were greater than upstream and downstream temperatures. However, temperatures at both HC-A(13) and HC-A(14) appeared to remain consistent with their observed daily fluctuation levels.

5.2 Water Temperature Impacts from Stormwater Management Pond 4

Water temperatures in Tributary A were elevated during the summer of 2013. Exceedances of 22.0°C were noted at 10 of the 11 surface water monitoring stations while exceedances of 24°C were noted at eight of the 11 stations. This issue was initially identified in 2012 during which exceedances of both 22.0°C and 24.0°C were reported at nine of the 11 surface water monitoring stations along Tributary A and Tributary A1 of Hanlon Creek. These exceedances were attributed to a combination of climatic conditions and issues related to SWM Pond 4. In 2012, air temperatures for the summer months were compared to previous monitoring years and the Canadian Climate Normalsandobserved to be above average and precipitation was below average between March and October.This resulted in a relatively hot and dry year overall. In addition,groundwater and surface water monitoring results also indicated that warm water was continuously discharging through the SWM Pond 4 cooling trench outlet. Groundwater monitoring results also showed a warming trend in monitoring wells located along the groundwater flow path between SWM Pond 4 and Tributary A. This combination of climatic and SWM Pond 4 factors led to the exceedances noted above and the overall warming of Tributary A downstream of the SWM Pond 4 outlet in 2012.

Although exceedances were still observed at a similar number of stations in 2013 compared to 2012, surface water monitoring results showed a decrease in the frequency and overall duration of 22°C and 24°C exceedances at all stations. It was generally observed that temperatures remained higher at stations found farthest downstream, similar to pre-2012 conditions. However, the trend of increasing temperatures at reaches downstream of SWM Pond 4, discussedas an issue in the 2012 consolidated monitoring report (NRSI 2013b),continued throughout 2013. HC-A(04), HC-A(06) and HC-A(09) all continued to experience extended periods above 24°C, albeit to a lesser extent than in 2012.Between July and August of 2012, stations HC-A(04) and HC-A(06) exceeded 22.0°C a total of 61.0% and 46.0% of the time, respectively and exceeded 24.0°C a total of 12.0% and 13.0% of the time, respectively. In 2013 both of these stations exceeded 22.0°C a total of 7% of the time, and exceeded 24°C a total of only 1.0% of the time. These decreaseswere partially a function of the increased average baseflows throughout Tributary A in 2013. However, these numbers are still higher than what was observed in 2011 when no exceedances of 24.0°C were observed and the 22.0°C threshold was only exceeded at HC-A(04) and HC-A(06) a total of 2.0% and 4.0% of the time, respectively.

In 2010 summer water temperatures were even lower. HC-A(04) didn't exceed either of the 22°Cor 24°C thresholds at all while HC-A(06) only exceeded the 22°C a total of 1.3% of the time.

Overall, an improvement was seen in the suitability of the thermal regime within Tributary A and A1, as shown through the temperature classification summary (Table 4). In 2013, all stations returned a colder classification than what was experienced in 2012, suggesting an improvement in the conditions within Hanlon Creek as they relate to Brook Trout habitat suitability. Many stations exhibited similar, and in some cases slightly colder classifications than what was seen prior to 2012 as well. The exception to this was stations HC-A(04) and HC-A(06), which show cooler classifications than 2012, but overall warmer conditions than what was seen between 2006 and 2011. The elevated water temperatures that were observed in Tributary A of Hanlon Creek are still of concern when considering the goal of maintaining a suitable thermal regime for brook trout, a cold water fish species that inhabit the Hanlon Creek system.The thresholds of 22.0°C and 24.0°C that were set in the Hanlon Creek Business Park Consolidated Monitoring Plan (NRSI 2010) represent the maximum allowable water temperatures for brook trout. As a result the water temperatures observed in 2013remain above the suitable temperature conditions for brook trout, which aredocumented in the *Hanlon Creek Business Park Stream Temperature Impact Report Continuous Modeling with HSP-F* (AECOM 2009).

Surface water monitoring stations upstream and downstream of the SWM Pond 4 outlet continue to indicate that the water flowing from the Pond 4 cooling trench is acting to increase temperatures within Tributary A.This remains true even though it was demonstrated that the cooling trench did have a moderating, and generally cooling, effect on the flow discharged to Hanlon Creek Tributary A from Pond 4 during storm events. Nevertheless, the cause of the increased water temperature in Tributary A continues to be associated with a combination of factors. The first cause includes the continuous discharge from SWM Pond 4 that was experienced throughout 2013.A secondary possiblecause that was identified in 2012, and which continued in 2013,involved the warming of the groundwater adjacent to SWM Pond 4. Thesecausesare discussed below.

5.2.1 Warm Water Discharging Through Pond Outlet

Monitoring results clearly demonstrated that a warming effect was continuing to take place in Tributary A at the location of the outlet of SWM Pond 4. The outflows from SWM Pond 4 were typically 3.0 -6.0°C warmer than the water temperatures in Tributary A, upstream of the outlet.

The cooling design features at SWM Pond 4 resulted in outflows that were often more than 5.0°C less than the surface temperatures of the pond. The temperature of the water discharging through the bottom-draw outlet of the pondwas generally lower during summer months than water temperatures at higher elevations within Pond 4, indicating that the bottom draw outlet successfully allowed for the discharge of the coldest (deepest) water first. The temperature recorded at the outlet of the cooling trench tended to have the least variation. As a result it was apparent the cooling trench did have a moderating, and generally cooling, effect on the flow discharged to Hanlon Creek Tributary A.

Despite the proven function of the bottom draw outlet and the cooling trench, temperatures leaving the pond were still higher than the threshold targets of 22.0 and 24.0°C. As a result, the water temperatures recorded at the creek station HC-A(04) downstream of Pond 4 were higher than those recorded upstream of the pond outlet. Station HC-A(04) exceeded the surface water thresholds numerous times throughout the summer months (July and August). In comparison, station HC-A(03), located immediately upstream from the outlet, did not exceed either the 22.0°C or 24.0°C threshold at all and only exceeded 19°C on one occasion.The continuous discharge from the pond also had a stabilizing effect on stream temperatures, because discharge temperatures remained elevated at night. Station HC-A(04) had a smaller magnitude of diurnal temperature fluctuations than those observed in the creek upstream of the pond outlet at station HC-A(03)and further downstream at HC-A(06). At station HC-A(06), daily peak temperatures were just as high as those of HC-A(04), but atmospheric cooling at night exerted a greater impact on the daily minima observed at HC-A(06).

Herbaceous species and vines were planted along the cooling trench in the fall of 2012. These were installed as an additional mitigation feature with the hope that they would grow over the rock lined cooling trench and reduce the impacts from solar radiation. It was determined that they provided little benefit during their first year as they covered only a small area of the trench, however it is important to note that they were not expected to provide full benefits within the first year. As these vines continue to mature and establish along the cooling trench it is anticipated that they will act to improve the overall effectiveness of the cooling trench. Monitoring in 2014 will provide additional insight into the benefits of this.

5.2.2 Warming of Groundwater Adjacent to the Pond

In 2012 it was determined that surface water from SWM Pond 4 could be migrating toward Tributary A through the ground as another pathway from SWM Pond 4 to Tributary A. In 2013 this continued as groundwater temperatures were found to be slightly elevated compared to pre-2012 monitoring, with the result that the natural discharge of groundwater to Tributary A in the vicinity of SWM Pond 4 could also cause increases in the temperature of Tributary A. The groundwater with elevated temperatures could also discharge through the cooling trench due to the groundwater interactions that lead to continuous discharge of groundwater through the trench.

Groundwater monitoring results continued to identify elevated groundwater temperatures at groundwater monitoring station MW119A. This monitor is located adjacent to and down-gradient from SWM Pond 4. Since the horizontal direction of groundwater flow is from southeast of the site, arcing towards the northern boundary, this monitor is located directly in the flow path between pond 4 and Tributary A. Groundwater temperatures across the HCBP site were generally observed to fluctuate within their typical ranges in 2013, with the exception of monitoring well MW119A. At MW119A groundwater temperatures ranged from a low of 5.0°C at the start of April, to a high of approximately 16.0°C in mid-September. This range is comparable to the ranges observed from 2008 to 2011. However, the highest temperature recorded in 2013 was just below the highest temperature that has been recorded, which was 17.5°C on September 5, 2012. Prior to construction of SWM Pond 4 in late 2010, the highest groundwater temperature at this monitor was 15.0°C in earlySeptember of 2010. The previous two years had reached a maximum of about 13.0°C in September.

The pond bottom is below the shallow groundwater surface and as a result, the un-lined pond is in direct contact with the local groundwater system. A portion of the water in the pond is interpreted to discharge from the pond as groundwater and flow in a north-westerly direction. Therefore, water in the pond warmed by solar radiation during summer months appears to have increased the groundwater temperature in the area down-gradient of the pond. Additional groundwater temperature monitors were installed down-gradient of Pond 4 in June of 2013.Groundwater temperatures at the new monitoring stations (PZ13-D and PZ-14D), which are located down-gradient of SWM Pond 4, were possibly influenced by the warmer water in this stormwater management pond in late summer. However, temperatures were only marginally above other comparable monitoring locations and they returned to normal seasonal temperatures by the end of 2013. Continued monitoring of groundwater temperatures in monitoring well MW119A, PZ-13D, and PZ-14D will be an important component of monitoring in 2014.

5.3 Change in Benthic Invertebrate Communityat Four Stations in 2013

Fourstations (BTH-001, BTH-003, BTH-004, and BTH-005) experienced threshold exceedances in 2013. Two stations (BTH-003 and BTH-004) exceeded the threshold for PMA analysis, which was an “Impact” determination at a station for two consecutive years following two consecutive years where the determination was “No Impact”;station BTH-005 exhibited a 50% decline in the total number of taxa as compared to the results from the previous year;and station BTH-001 exhibited a 50% decline in the number of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa as compared to the average results from the previous 2 years. These threshold exceedances are discussed below.

Benthic invertebrate threshold number 1 was reached at Stations BTH-003 and BTH-004 in 2013. At BTH-003 PMA analysis had consistently returned a result of “No Impact” between 2006, when sampling began, and 2011. An “Impact” determination in 2012 marked the first of this kind at this site, which was followed again by another “Impact” result in 2013. This resulted in a threshold exceedance. Prior to 2011 the results suggested that habitat and/or water quality conditions at station BTH-003 were generally improving as evidenced by a consistent increase in species diversity (taxonomic richness). Results in 2011 and 2012, however, suggested a change in the habitat conditions at this site leading to results that are similar to those observed in 2006. This was demonstrated through a decrease in taxonomic richness and EPT taxa richness, and a large increase in the proportion of the dominant taxon, *Micropsectra*spp in 2011, and *G.pseudolimnaeus* in 2012. However, since this change was consistent with pre-construction monitoring results in 2006, it was attributed to natural variation. Results in 2013 have remained similar to those in 2012 with the exception of a slight increase in EPT taxa. These levels are more similar to results from 2006, with the exception of the PMA ‘impact’ determination. In 2012, the PMA ‘impact’ determination was attributed to lower baseflows and variation in the natural conditions of the site, however conditions were markedly different in 2013 with higher than average baseflows and groundwater levels similar to what was experienced prior to 2012. In 2013 the two consecutive years of an ‘impact’ determination following two years of ‘no impact’ resulted in the exceedance of the first threshold. However, due to the differences in habitat conditions between 2012 and 2013 it is difficult to determine the cause of the exceedance. The slight increase in EPT taxa in 2013 indicates that the benthic community may be rebounding following a year of abnormal habitat conditions. Sampling in 2014 will provide a better understanding of the benthic community at BTH-003 and its responses to the changing habitat conditions.This threshold was also exceeded at BTH-004. However, sampling has only occurred here since 2009, resulting in an incomplete picture of aquatic conditions compared to Stations BTH-001, BTH-002, and BTH-003.Similar to BTH-003, lower baseflows and variation in the natural conditions most likely contributed to the ‘impact’ determination in 2012, but conditions were markedly different in 2013.

Benthic invertebrate threshold number 2 was reached at Station BTH-005 in 2013. This station experienced a decrease in taxonomic richness from 31 to 14, a decrease of 55% between 2012 and 2013. The remaining four stations also saw declines in taxonomic richness(48% at BTH-001, 47% at BTH-002, 27% at BTH-003, and 33% at BTH-004), although none were large enough to exceed the specified threshold of 50%. It is not believed that these declines, and specifically the threshold exceedance, were related to habitat conditions or construction-related activities throughout the HCBP in 2013. Instead, they are believed to be a result of the level of identification resolution used. In 2012 samples were sent to Richard Bland for identification while in 2013, samples were identified in the NRSI benthic lab as Richard Bland is retiring from full-time taxonomy services. Equipment available within the NRSI benthic lab allows for identification of most benthic invertebrates to family level, and many of these to species level. However, one family of benthic invertebrate, Chironomidae, which belongs to the order Diptera, require mounting the specimens on slides and using a compound microscope to achieve a much greater level of magnification to accurately identify organisms to species. As a result, Chironomids were identified to sub-family levelin 2013, while in 2012 they were identified to species by Richard Bland. The greater level of taxonomic resolution is generally not required for this type of benthic invertebrate analysis. A comparison of Chironomid sub-families between 2012 and 2013 shows that there were four sub-families present in each year. However, since these were further identified to species in 2012 there was a total of 23 Chironomid taxa identified, compared to four in 2013. When comparing the taxonomic richness values between 2012 and 2013, including Chironomids to subfamily only, there are no threshold exceedances observed. Declines in taxonomic richness were still observed at all five monitoring stations to varying degrees; however, since no threshold exceedances were noted with the adjusted numbers this is currently not a cause for concern.

Benthic invertebrate threshold number 3 was reached at Station BTH-001 in 2013. This station exhibited a greater than 50% decline in the number of EPT taxa as compared to the average results from the previous 2 years and resulted from a reduction in EPT taxa from an average of 19.4% between 2011 and 2012 to 9.1% in 2013, or a 53% decline. This threshold was exceeded for the second consecutive year at BTH-001. Between 2011 and 2012 a substantial decrease in EPT taxa was experienced at BTH-001, which saw proportions decline from 27.0% to 11.9%. This continued into 2013, albeit to a much lesser extent, falling from 11.9% to 9.1%. However, this still represents the lowest EPT richness value that has occurred at this station with the highest occurring in 2008 (41.8%). The majority of years show that EPT proportions at BTH-001 typically range from approximately 20.0% to 25.0%, which include preconstruction (2006 and 2007) and during-construction (2010 and 2011) years. Analysis of the other calculated benthic metrics provides further insight into the conditions at station BTH-001. PMA analysis returned a result “no impact” once again in 2013. This has been a consistent result since sampling began in 2006 as no “impact” designation has ever been observed at this location. The dominant taxon found at the site was *Orthocladiinae spp.*, a subfamily of Chironomidae. This is the first year that this particular subfamily has dominated the sample. In 2006 and 2007, under preconstruction conditions, the dominant taxon wasfound to be *Microspectra spp.*, a genus of the subfamilyChironominae, indicating that dipteran families have consistently contributed a large proportion to the overall sample at BTH-001. The habitat conditions at station BTH-001 are consistent with thegeneralized habitat preference of this family, providing silt, sand and gravel substrates, as well as moderately abundant detritus and woody debris. *Orthocladiinae spp.* exhibit a range of tolerances as it relates to water quality. However, in general they are indicative of good water quality (Mandaville 2002).This subfamily of Chironomid was also noted to be the dominant taxon at BTH-005, which is located upstream of BTH-001 and in closer proximity to the outlet of SWM Pond 4. The continued decline in EPT richness does not appear to be a result of influences from SWM Pond 4 because BTH-005 did not experience the same threshold exceedance. While its EPT taxa were nevertheless reduced by 16% compared to the average of the previous two years, its EPT taxa result is within the range of past years' results. Station BTH-005 also had a "no impact" PMA result and its exceedance for taxonomic richness is explained by the taxonomic resolution used for analysis in 2013, providing further evidence that SWM Pond 4 is not negatively impacting the benthic community in Tributary A. As there is no other clear connection with construction activities, the exceedance at BTH-001 is most likely attributable to the natural variation in the community and/or sampling variation.

This EPT taxa threshold was also exceeded in 2012 at three stations: BTH-001, BTH-003, and BTH-004, resulting from substantial declines in EPT values to the lowest levels observed at the three stations since monitoring began. The proportions of EPT taxa rebounded in 2013 at BTH-003 and BTH-004, increasing to numbers that were more comparable to previous years.

5.4 Change in Herbaceous Cover by 25% at Two Stations in 2013

In 2013, the 25% threshold was exceeded in Plots 2 and 3. The Plot 2 threshold was exceeded positively due to an abundance of spotted jewelweed and has been interpreted as a positive change within the plot. The herbaceous cover in Plot 3 (9.1%) was reduced by almost 49% from the preconstruction average (57.8%). Plot 3 is situated within the retained central wetland complex and well removed from any of the construction activities that have taken place to date. As this plot is outside of the construction areas this change in herbaceous vegetation cover is difficult to explain. However, variation may be a result of dry conditions observed during the spring of 2012 affecting vegetation, or an increased presence of herbivores, in particular white-tailed deer. Conversely, ideal soil moisture and climatic conditions during pre-construction monitoring years may have produced an abundant cover of herbaceous species within the plot, in particular ostrich fern. The 2012 Groundwater Monitoring Program Report prepared by Banks Groundwater Engineering Ltd. (2013) notes that due to below average precipitation, groundwater levels have been declining throughout the site since monitoring began in 1997. Below-average annual precipitation occurred in 2007, 2009, 2010 and 2012, with 2012 being the fourth-lowest recorded amount from 1971 (Banks Groundwater 2013). The herbaceous layer in Plot 3 is dominated by ostrich fern, a species with a coefficient of wetness of -3, meaning that it relies on moist conditions to survive. At this time it is believed that recent years of below-average precipitation are responsible for the decrease in ostrich fern within the plot and subsequently a decline in herbaceous cover.

5.5 Change in Herbaceous Species Diversity by 25% at Five Stations in 2013

In 2013, an increase by more than 25% was observed at Plots 1, 2, and 6 and 9 while a decrease of more than 25% was noted at Plot 5. An increase in species diversity is generally associated with a benefit to the natural environment, unless the increase is due to an introduction of a non-native, invasive species. An analysis of non-native invasive species revealed that non-native species diversity has remained relatively steady within all plots since 2006 (with minor annual fluctuation from year to year). Non-native species should continue to be monitored in subsequent years, however it should be noted that in most cases, their presence predates the beginning of construction on site. Ongoing monitoring will continue to assess the increase or decrease in species diversity including an analysis of non-native species within each plot. Similar to previous monitoring years, non-native species were recorded in all plots in 2013, except Plot 5.

Over the course of 8 years of plot monitoring, Plot 1 and Plot 6 continue to show a clear trend of increased species diversity and this has been attributed to their proximity to areas which were previously cultivated or managed as hay fields and have since naturalized. Despite the observation of only 5 species in Plot 5 in 2013, it should be considered that this plot shows consistently low species diversity due in part to a dense canopy of conifers. Herbaceous species in this plot tend to exist sporadically in low numbers and may be present one year yet while they have senesced or died off in another, less favourable year. Increases in species diversity are generally seen as a positive change to vegetation communities.

5.6 Decline in Amphibian Species Abundance at Three Stations in 2013

A decrease in two calling codes was established as the threshold in the HCBP Consolidated Monitoring Program (NRSI 2010). These decreases were observed at three plots in 2013; Plot 4, Plot 16, and Plot 18 and have been described below.

- American toad in Plots 4 and 18 – no individuals recorded in 2013, down from a call code 2 and a full chorus of 3 (respectively) recorded at these plots in 2012,
- green frog in Plot 16 – no individuals recorded in 2013, down from call code 2 recorded in 2012,
- northern leopard frog in Plot 16 – no individuals recorded in 2013, down from call code 2 at this plot in 2012,
- pickerel frog in Plot 16 – no individuals recorded in 2013, down from call code 2 at this plot in 2012,
- western chorus frog in Plot 16 – no individuals recorded in 2013, down from call code 2 at this plot in 2012.

A review of the 2013 field notes and incidental observations of American toad indicates that the species is still widespread and common within the subject property. However in recent years more observations of this species have been made from within the SWM ponds. Habitat and forage opportunities for the species may be ideal within the SWM ponds and the movement of individuals from natural features to constructed features should not be regarded as a negative impact given that suitable natural habitat is still present within the site.

The remaining identified species, green frog, northern leopard frog, pickerel frog and western chorus frog have all been observed intermittently within the subject property dating back to the 2007 monitoring year. Generally these species have been observed in low numbers at a call code of 1 or 2. With the exception of a single pickerel frog observed in 2010, none of these species were observed within the plots in either of 2010 or 2011. It is likely that these species have always existed in low numbers within the property and are subject to natural population fluctuations.

A number of the species abundance decreases which surpassed the threshold occurred in Plot 16 which was noted previously for decreases in herbaceous vegetation and bird species diversity. It is likely that the changes observed in this plot are a result of dry conditions in 2012 coupled with the nearby construction activity. Although Plot 16 showed a relatively high diversity of calling amphibians in 2012, dry conditions may have led to desiccation of egg masses or tadpoles, increased mammal predation or the movement of adult anurans to other vernal pools in search of better breeding habitat. The low levels of anuran activity in Plot 16 in 2013 may be a reflection of impacts sustained during the spring of 2012. It is also possible that the installation of sediment fence surrounding the feature may have acted as a barrier to amphibian movement between the core natural feature and the swamp at Plot 16.

6.0 Summary of Corrective Measures Undertaken

No corrective measures were undertaken in 2013. The RAAP group met throughout the year to identify issues that arose regarding SWM Pond 1 and SWM Pond 4, however based on discussions between the group it was determined that no contingency measures should be put in place. Instead, it was decided that the corrective measures undertaken in 2012 should continue to be monitored for effectiveness throughout 2013 and into 2014 before making any changes. The corrective measures undertaken in 2012 included: raising the outlet of the cooling trench at Pond 4 (this was removed in early 2013), raising the weir level at the pond outlet at Pond 4, and planting of aquatic vegetation throughout the shallow areas of the pond as well as planting vines and herbaceous species in and around the cooling trench at Pond 4. The decision to wait on implementing additional corrective measures was based on the fact that the vegetation planted in 2012 can take several year (3+) to become well established and mature in order to function as intended.

7.0 Recommendations

7.1 Actions for 2014

No additional actions are recommended to occur in 2014, apart from future monitoring recommendations identified below in Section 7.2.

7.2 Future Monitoring

2013marked the fourth year of construction-phase monitoring at the HCBP. The following recommendations for monitoring are made with this in mind.

It is recommended that monitoring continue with diligent attention given to stream temperatures and the SWM Pond 4 mitigation measures put in place to date, using the RAAP as prompted by any stream temperature or turbidity exceedances. This will ensure that attention is given to any ongoing patterns in stream temperature, and actions can be taken if deemed necessary.

The long-term groundwater monitoring program at the HCBP site should continue in 2014on a quarterly basis as previously recommended. Particular attention should be given to monitoring wells MW119A,PZ-13D, and PZ-14D regarding the temperature effects of SWM Pond 4. Groundwater samples should continue to be collected from selected monitoring wells and analyzed for the established water quality parameters.The improved filtering of water samples should be continued as standard practise.

The surface water monitoring program during and post construction should continue in 2014 as per the Standard Operating Procedures for the Consolidated Monitoring Program (NRSI 2010) to ensure temperature targets are met and water temperatures aresuitable for brook trout. Monitoring of stormwater management ponds should also continue as in 2013 to monitor their effectiveness, including the bottom draw outlet and cooling trench performance.It is recommended that the temperature loggers in the Pond 1 cooling trench outlets be replaced with depth/temperature loggers to determine the relative flows out of each cooling trench to establish if one or the other cooling trench may be passing more flow and influencing temperatures more. It is recommended that the depths of loggers at loggers at HC-A(11) and HC-A(14) be adjusted in 2014 to avoid sediment overcoming the sensors and that turbidity sensors be maintained more frequently to ensure usability of data.

Fish and benthic invertebrate monitoring should continue to occur in 2014 as per the Standard Operating Procedures for the Consolidated Monitoring Program (NRSI 2010). Particular attention will be given to benthic stations that experienced threshold exceedances in 2013 as additional monitoring data is expected to help explain the variety of changes that have been observed within the benthic community.

Vegetation monitoring should continue as per the Standard Operating Procedures for the Consolidated Monitoring Program (NRSI 2010), with the following notes for 2014. Special attention should be given to Plot 3, which has exhibited a consistent decrease in herbaceous cover over the past eight years. As this plot is far-removed from construction activities these changes are likely a result of natural fluctuations in herbaceous species cover due to annual declines in precipitation, coupled with the possibility of deer browse but should be still be carefully observed.

Monitoring of the aquatic and riparian vegetation within the SWM Pond 4 and herbaceous plants along the cooling trench should also occur throughout 2014 starting in the spring in order to monitor the survival and establishment of the vegetation planted in the fall of 2012.

Breeding bird and amphibian monitoring should continue in 2014 as per the Standard Operating Procedures for the Consolidated Monitoring Program (NRSI 2010).

8.0 Conclusions

Monitoring at the Hanlon Creek Business Park in 2013 was successful in providing useful information to describe environmental conditions on site, detect issues and develop solutions. Elevated stream temperatures and the contributing temperature impacts from SWM Pond 4 continued to be the most prominent issue in 2013. As such, monitoring in 2014 should give particular attention to this issue through the continued monitoring of new wells and the effectiveness of the planted vines and aquatic vegetation. The RAAP group should also carefully review any stream temperature threshold exceedances. The standard operating procedures for data collection are expected to provide the information required to further address the issues discussed in this report. The issues and conclusions identified in this report will be further analyzed through future monitoring and subsequent recommendations.

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APPENDIX I

CONSTRUCTION INSPECTION REPORTS

APPENDIX II

GROUNDWATER MONITORING REPORT

APPENDIX III

SURFACE WATER MONITORING REPORT

APPENDIX IV

AQUATIC MONITORING REPORT

APPENDIX V

TERRESTRIAL AND WETLAND MONITORING REPORT

APPENDIX VI

RAPID ASSESSMENT AND ACTION PROTOCOL DOCUMENTATION